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NUTRITION AND PHYSICAL EFFICIENCY.*

BY

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ONE of the most awe-inspiring mysteries which the mind of man can contemplate is the power possessed by a tiny mass of matter, the fertilized egg, to develop in a harmonious manner into a composite structure containing tissues and organs with highly specialized functions. Then there follows in all higher animals a period of growth during which the most marked change is an increase in size, but during which there are minor changes in form and structure. No less mysterious is the power of living matter to take from its surroundings food material of a lower grade of organization than itself, and while undergoing continuous destruction through hydrolysis and oxidation, to utilize this food for rebuilding its structures and maintaining its functional capacity unimpaired.

The full-grown man or animal enjoys a period, which varies greatly in length in different species, during which there is no observable decrease in physical power. Ultimately, however, the functional capacity of the tissues diminishes and there sets in a period of involution which is accompanied by changes which we recognize as characteristic of old age.

It is a matter of common observation that the different types

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and races of man, living in different parts of the world and subjected to widely different climate, and engaged in unlike pursuits in order to gain a livelihood, are not all equals either physically or mentally. Herbert Spencer once said that "to be a nation of 'good animals' is the first condition to national prosperity." We can all readily accept this view, but on reflection would agree with Lord Rosebery that "an empire is but little use without an imperial race."

Various attempts have been made to account for the differences in achievement of man in the several parts of the world. Some investigators regard race as the most important factor, and believe that certain races are naturally inferior to others. Huntington of Yale University attributes to climate the most important role in determining the efficiency of man in the several regions of the world. Numerous authors have emphasized the importance of a satisfactory diet for the maintenance of health and of physical fitness, which all agree forms the fundamental basis of achievement. No one up to the present time has, however, been able to make a very strong case in favor of nutrition as a factor. This is witnessed by the number of dietary systems and fads which have been offered to the public. While one enthusiast extols the virtues of abstemiousness, another warns against it and points to the high meat consumption of the successful nations of the earth. While thousands of dyspeptics adopt vegetarianism, others explain the remarkable health of centenarians as due to the bacillus of sour milk.

The general public becomes suspicious when approached by a multiplicity of counsellors seeking favorable consideration when the character of their advice is bewildering. The trouble lies in the lack of definite and accurate knowledge concerning the chemistry of nutrition which has prevailed until very recent times. While many of the wisest philosophers would agree with the statement expressed editorially by the *British Medical Journal* in 1904, "The study of dietetics should be looked upon as very nearly if not quite as important as the study of therapeutics," much disagreement would, nevertheless, be encountered in their views as to the best dietary habits to adopt. Fortunately chemistry has come to rescue dietetics from its state of empiricism. In the hands of the chemist new methods of experimentation have been developed which have made possible the solution of

problems of detail which were not dreamed of in the philosophy of dietitians. Before discussing the relation of the diet of man to his well-being and efficiency I want to explain the simple procedure which has brought order out of chaos in the field of nutrition.

The best chemical analysis of a food-stuff which the chemist is able to make determines the amounts of protein, carbohydrate (starches and sugars), fats and oils and mineral salts which it contains. For more than thirteen years it has been known, however, that when a mixture of this list of substances, each carefully purified, is fed to a young animal the latter cannot grow or long remain alive. The reason for this was very difficult to ascertain, for it is due to the lack of certain substances of a moderately unstable nature, the existence of which was not suspected. Certain species of animal, as the rat, appear to require, in addition to the long-recognized dietary complexes, but two of the unidentified dietary essentials. The most common designation of these is perhaps the term "vitamine," which includes fat-soluble A and water-soluble B. No less than twenty-five names have been invented for these substances. Other species of animals, such as man, guinea-pig and monkey, require three, the additional one being called water-soluble C. These terms have been applied provisionally pending the discovery of the chemical natures of these interesting substances.

Modern research has shown that there are very great differences in the biological values of the proteins from different sources. This difference depends on the fact that the proteins in different food-stuffs yield varying amounts of the amino-acids or digestion products. If the yield of the several amino-acids is such as to make possible the efficient transformation of food proteins into tissue proteins the proteins have a high value. If, however, one or more of the amino-acids is present in such small amounts as to make it impossible to utilize the more abundant amino-acids, they form the limiting factor which determines the value of the protein in nutrition. Many of these digestion products are certainly indispensable in the diet, since they cannot be synthetically produced within the tissues. In considering the value of a natural food-stuff or of a diet consisting of a variety of substances, the idea of quality of protein enters into the calculations of the dietitian of to-day.

It has been abundantly demonstrated that the mammal requires for satisfactory nutrition nine mineral elements in addition to the essential organic complexes, in order that its diet may be adequate. These are calcium, magnesium, sodium, potassium, chlorine, phosphorus, sulphur, iron and iodine. These can be supplied in the form of inorganic salts except in the case of sulphur which must be contained in the diet in the form of the sulphurized amino-acid cystine. It is doubtful if there is an order of relative importance among these, for it appears that all are indispensable. There must be present in the diet either glucose or a carbohydrate which can be converted into glucose in the body. Cane sugar, glucose, beet sugar and the starches serve this purpose.

It seems highly probable that fats and substances closely related chemically to the fats are entirely dispensable in the diet. Up to the present time it has not been found possible to properly nourish an animal with a diet free from this class of compounds because one of the unidentified dietary essentials is associated only with certain fats. Therefore, in working with a diet made up of purified food-stuffs it has been necessary in every case to add one of these fats, not because of the fat itself, but because of the presence of an unknown substance (fat-soluble A) which is contained in it.

It will be interesting to inquire about the distribution of the three unknown substances which the diet must contain. The substance fat-soluble A is found in butter fat and egg yolk fats, and in the fats from the interior of the cells of the glandular organs of animals (*e.g.*, the liver, the kidney) in greater abundance than in any other foods. The next foods in importance as a source of it are the leaves of plants. The seeds, tubers and fleshy roots are relatively poor in this substance.

The water-soluble B dietary factor is widely distributed among natural food-stuffs. The only foods which are in common use which are lacking in it are polished rice, the sugars and starches, and the fats and oils from both animal and vegetable sources. A group of foods which are very poor sources of it are white flour, degerminated corn meal, macaroni, spaghetti, and other products prepared principally from bolted wheat flour. All whole seed products, tubers and fleshy roots, leafy foods, milk and eggs contain it in relative abundance. Muscle cuts of meats are very poor in it, but the glandular organs contain it in abundance.

The water-soluble C is abundant only in fresh vegetables, fruits and fresh milk from cows which are on pasture. Cooked and dried foods have in great measure lost their peculiar dietary properties with respect to this substance.

The effects of specific starvation for one or another of these three substances are of special interest. Each of them is necessary in the diet in order to prevent the development of a specific syndrome which we call collectively deficiency diseases.

One of these, which is caused by a lack of fat-soluble A in the diet, is characterized by a change in the eyes, in which edema, inflammation, and in some cases perforation, are the most important. Much remains to be learned regarding the histology and pathology of starvation for this dietary complex. Without it growth is impossible, and death soon supervenes. There is much evidence that a lack of a sufficient amount of fat-soluble A is one of the factors associated with the etiology of rickets.

A lack, either relative or absolute, of the second dietary factor of unknown chemical nature, water-soluble B, leads to the development of a condition of polyneuritis which in man is known as beri-beri. The paralysis is the most striking general feature of the disease.

The third of the dietary complexes under consideration is that which prevents when it is present in the diet the development of the syndrome of scurvy. It is the least stable of the three. The antineuritic substance is the most stable.

For several years the three substances just discussed have in the popular mind overshadowed in importance the long-recognized dietary essentials. It should be emphasized at once that there is no basis in fact for considering them any more important than the proteins or than any one of the essential mineral elements. All are indispensable components of the diet, and are, therefore, of essentially equal importance. Any appraisal of the quality of the diet must include a consideration of the quality and quantity of protein; the content of each of the necessary mineral elements; the content of each of the substances which are concerned with the etiology of the deficiency diseases, and the availability of its carbohydrates.

After the factors which operate to make a diet complete and satisfactory were appreciated, a series of studies were carried out with a view of determining the nature and extent of the dietary

shortcomings of each of the more important of our natural food-stuffs. In the light of these studies it has become possible to make certain generalizations which are of far-reaching importance in the nutrition of man and animals. On these observations is based a new type of classification of the vegetable food-stuffs depending on the function of the part of the plant from which they are derived.

It has been found that all those parts of plants which have the functions of storage tissues, *viz.*, the seed, tuber and fleshy root, have remarkably similar dietary properties and similar shortcomings. Notwithstanding the great difference between the legume seeds, such as the pea and bean on the one hand and the potato or turnip on the other, they have very nearly the same dietary values in certain respects. All of the cereal grains, legume seeds, tubers and edible roots are deficient in some degree in at least three dietary factors. All contain proteins of relatively poor quality; all contain too little of certain mineral elements, especially calcium, sodium and chlorine, and all are deficient in fat-soluble A.

The leaf of the plant possesses very different dietary properties from the seed. The palatable leaves are alone a complete food for those types of animals which have digestive tracts sufficiently capacious to enable them to eat a sufficiently large amount to meet their energy requirements. This superiority in dietary properties correlates with the special function of the leaf as contrasted with the storage tissue, as the seed, tuber or root. The leaf consists of actively functioning protoplasm supported by skeletal tissue. It is the seat of the synthesis of proteins, carbohydrate and fats. It is the seat of active respiration and metabolism. The seed, tuber and fleshy root represent on the other hand packages of reserve food materials, with few living elements. In general the structures of the storage tissues do not contain all the complexes necessary for the construction of living protoplasm, and are accordingly incomplete foods.

A similar parallel between function and dietary properties can be drawn in the case of the highly specialized muscle tissue on the one hand and the actively metabolizing glandular tissues on the other. The muscle tissue has dietary properties almost identical with the seed, tuber or root in all respects except its richness in protein. It lacks sufficient calcium, sodium and chlorine.

fat-soluble A, water-soluble B, and water-soluble C. The glandular organs such as the liver and kidney are much more nearly complete foods. Indeed, they have all the complexes which are essential for the construction of living tissue, and when supplemented with a carbohydrate, such as starch, approximate much more nearly a complete food than would a similar amount of muscle tissue with starch.

Since there are closely similar dietary properties in the storage tissues of plants and of muscle tissue of animals, it should be expected that mixtures of these even in considerable numbers should not form satisfactory diets. This has been shown in many feeding experiments to be the case. Although it is possible for a young animal to grow on a seed, tuber, root and muscle cut of meat diet, its growth is never normal in rate or extent. It will always be stunted, and will fall below the normal standard of performance in reproduction and rearing of young, and in span of life.

Consistently unsatisfactory results have been secured on diets consisting of wheat flour, corn meal, rice, peas, beans, potato, turnip, beet, rolled oats and round steak. The round steak was included to the extent of ten per cent. of the dry matter of the diet.

This leads us to a consideration of the kinds of diets which do succeed in the nutrition of animals. In a very extensive inquiry, covering twelve years, and based on nearly four thousand feeding experiments, we have succeeded in nourishing animals in an approximately normal fashion with but three types of diets.

It is possible to so select carnivorous foods as to secure a fairly satisfactory diet entirely derived from animal tissues. Young animals cannot grow or long remain in health when restricted to muscle tissue as their sole food. When blood, liver, kidney and other glandular tissues are selected, together with a certain amount of bone substance, the food supply is sufficiently good to lead to normal development. Muscle tissue must be liberally supplemented with blood or glandular organs and bone to make possible success with the strictly carnivorous diet. The carnivorous diet has been used by man occasionally, the Eskimo and some American Indians being examples.

It has been found possible to supplement the seed, tuber, root and muscle meat type of diet with liberal amounts of the leafy

vegetables and secure a fairly satisfactory diet. This requires a liberal supplementing with leaf in order to make good the deficiencies of the remainder of the diet. This type of diet is common among the Orientals.

The third type of diet which succeeds is that derived from cereals, legume seeds, tubers, fleshy roots, with or without meats, supplemented with liberal amounts of milk. Milk is so constituted as to make good all the deficiencies of the classes of foods just enumerated.

It is so important to appreciate the special qualities of the leafy vegetables and milk that I have been accustomed to designate these as the *protective foods*. They are protective foods because they are especially rich in just those elements and complexes in which the storage tissues of plants and muscle tissue are poor.

We will now turn our attention to the application of the facts discovered through animal experimentation to human problems. On careful consideration it strikes one that the more advanced peoples of the world are those who live on the vegetable and meat diet supplemented with milk and its products. The second class in respect to advancement and aggressiveness are those which eat liberally of the leafy vegetables. All strictly carnivorous men live in climates which preclude the development of any high degree of civilization. They have nothing to strive for further than food, shelter, and clothing, and do not accumulate much property.

There can be no doubt that there are carnivorous animals, such as the lion, tiger and jaguar, which live in the hottest parts of the world, yet represent some of the best examples of physical development in the animal kingdom. Neither the heat, monotony of high temperature, humidity or aridity can be said to interfere with physical development.

The tiger thrives in the wet estuaries of Bengal, and the jaguar in the hot and sultry forests of Brazil. The lion is equally vigorous on a margin of the desert. We can find no evidence that climate is a factor of any appreciable importance in the develment of lower animals so far as physical well-being is concerned.

Huntington has made a very plausible case for climate as the most important factor in determining the efficiency of man in the different regions of the world. He points out that the changes in the condition of the weather so characteristic of the northern

parts of the United States and lower Canada in the western hemisphere, and of England, northern France, Holland, southern Germany, etc., are the ideal conditions for stimulating effort, both physical and mental. This assertion he bases upon careful observations on the amount of work of several kinds which workers accomplish in climates varying from that of Connecticut to Florida. Temperature he finds to be the important factor in determining the aggressiveness and ambition of the individual. The farther south the more uniformly warm it is, and the more the climate departs from the typical cyclonic stormy type so characteristic of the northern states of England.

Huntington further correlates the character of the climate of Europe, Asia, Africa, and North and South America, with the state of advancement of their peoples, and finds a remarkable relationship between them. Monotony of climate over long intervals is said to be detrimental to achievement. He eliminates race as an important factor in determining the problem by pointing among other illustrations to the condition of the white people of the Bahamas, who are the descendants of virile Southern settlers, as contrasted with that of other loyalists who at the time of the revolution emigrated to Canada. The former have degenerated into "poor whites" who are too proud to work at menial labor in competition with the negro, and too shiftless to compete with him successfully. The latter are among the most prosperous and progressive citizens of one of the finest examples of a commonwealth in the world.

Huntington sees no great hope for the future of civilization in Asia, Africa or South America, because the white man, who is regarded as superior to the other races, degenerates in their enervating climates. The view is held that when the white man migrates to climates less stimulating than those of his original home, he appears to lose both physical and mental energy. If it is true that under such influences man becomes careless of sanitation and of food, and thus secondarily becomes susceptible to diseases, then indeed there is little reason to hope that the dream of the hygienist can be realized that the tropics can ultimately be made the abode of a cultured population.

Plausible as is the correlation between climate and civilization which Huntington has constructed, it seems to me that another interpretation can be placed on all the data which he presents,

which in the light of what we now know about the effects of diet on health will come nearer the truth. In order to appreciate the importance of diet on the welfare of nations we should consider for a moment the effects of certain types of faulty nutrition on the life history of experimental animals.

When a full-grown animal such as a rat is placed on a diet of seeds, tubers, fleshy roots and muscle meats, it begins to hurry through its span of life, developing the characteristics of old age at a rate double or more the rate observed in a well-nourished animal. It does not succeed well with the nutrition of its offspring, and dies at a fairly early age. The young, if restricted to the diet of the parents, are never their equal physically, have poor success with their young, *live much less long* than the species is capable of, and are subject to infections and abnormalities in a degree unknown in their ancestors. With each succeeding generation weaklings predominate, and the strain dies out within a few generations.

If we apply to the natives of the Bahamas the test of nutrition we find that the diet is of such a character as to account for degeneration in considerable degree within the period since the islands were settled by loyal Tories who were not willing to live under the Stars and Stripes. During this period they have depended for their food supply largely on citrus fruits, pomegranates, pineapples, bananas, melons, yams, potatoes, guinea corn and peas. This it will be noted is a list consisting of fruits and other storage tissues of plants. It has been supplemented with a certain amount of animal foods, principally fish, although some muscle meats from mammals have been eaten. This type of diet it will be remembered is unsatisfactory for the nutrition of an animal over many generations, and leads to deterioration in the stock. This is the condition found in the Bahamas.

On the other hand the people of Canada have lived essentially on the same type of diet as that employed in the northern United States. It includes all the products of field and garden with which we are familiar, together with meats in liberal amounts and dairy products in moderate quantities. The latter is the kind of diet which supports the civilization of England, and also the most progressive European countries as well as that of the northern United States and all other parts of the world which have been peopled by colonization from European stock, wherever the climate will permit.

Another example of the failure of health of European people largely as the result of restricted diet improperly selected is found in Newfoundland and Labrador. There occurs in both these districts the deficiency disease beri-beri, which is caused by lack of a sufficient amount of the dietary essential water-soluble B. The disease is the same that is seen so frequently among the poor laboring classes of the Orient who subsist largely on a diet of polished rice and fish with a few vegetables. The diet in Newfoundland consists, according to Dr. Little, of bread made from bolted wheat flour, tea, fish and salt meats, and raisins. A similar food supply is all that is available in Labrador.

There seems good reason to believe that a second deficiency disease actually occurs among the people of both these regions as the result of their restricted and faulty diet. I refer to a condition popularly called night blindness, which is common especially among men who are out at sea for a considerable period and are subjected to a fare of poorer quality than that obtainable at home. I cannot affirm that it is demonstrated that this is incipient xerophthalmia due to a lack of the unknown dietary complex found most abundantly in butter fat and a few other fats, but there is good reason to believe that it is. Night blindness occurs among men in lumber camps in Canada and elsewhere, and the popular local remedy is to feed the patient milk or cheese. Prompt recovery is said to follow this modification of the diet. In these camps the food supply is frequently limited to bread, salt or canned meats and peas or beans for considerable periods. This again is a seed and meat diet and has been found to be unsatisfactory for animals and for man. The same condition appears to be occasionally met with in Japan, and is not uncommon in parts of India. In both of these countries the popular remedy is the free use of liver as a food, and in India it is recommended that a poultice of liver be applied to the eyes as well. It is safe to say that it is the consumption of the glandular tissue that results in benefit to the eyes of the sufferer. In Japan eel fat and chicken livers enjoy the reputation of being efficacious in the cure of xerophthalmia. Night blindness is reported to be met with in Russia somewhat commonly during the latter part of the Lenten fast. During this period the people restrict their diet largely to cereals, and fail to secure enough of the dietary factor which is concerned with the deterioration of the eyes.

According to the views of those who believe that climate in itself is the chief factor in determining the progressiveness of a people, it will never be possible for a people in central Asia to develop a high state of civilization. It seems worth while to examine into the validity of this conclusion, and in doing so we must make it clear what conditions we accept as a fundamental basis of civilization. If physical well-being as exemplified in excellent development, together with courage and energy, be the first requisite, we have had in the past and have now some notable examples of it among the central Asian tribes. It is necessary, however, in order that a high degree of civilization shall be reached, that a relatively high stage of mental development, together with both social and political fixity, shall be attained.

Of fundamental importance for the development of a highly organized society and a state of advanced civilization is the right kind of religion, since this determines the mental attitude of the individual toward his associates, his neighbors, and his own destiny.

The Mongol hordes of central Asia in the thirteenth to the sixteenth centuries overran and conquered much of western Asia and Europe as far westward as the boundary of Austria-Hungary. Eastward they overran a large part of China, and to the north they were for generations a thorn in the side of the Russians. These Mongols, who played so prominent a part in history, were typical representatives of the sour milk drinkers so common among the pastoral people of all parts of Asia and eastern Europe. At the present time the natives of northwest Mongolia have many cattle, sheep, horses and camels, and derive their sustenance almost entirely from their flocks and herds. The Mongols had all the elements necessary for the creation of a high develop-ent of civilization except the mental attitude toward society which would permit them to respect the personal and property rights of others. They had not the sense of honor and the appreciation of the ethical relations between man and man which are necessary for the establishment of a stable society based on law and order and governed in the interests of the people. Such governments had not at that time gained popularity anywhere in the world. The frame of mind which makes possible these things can be attained only through the establishment of the best system of religion. Climate had nothing to do with these.

The ancestors of the present Turks were likewise a pastoral people and were sour milk drinkers. This constitutent of their diet would alone suffice to make it highly satisfactory, and to insure, in the absence of contagious or of insect-born diseases, an excellent physical development. Such a development is the essential basis of military ambition and success, and was possessed by both the Mongols and the Turks.

The Arab of to-day is an example of the effects of a diet in which sour milk finds a prominent place. He is described by all modern writers as singularly handsome, tall and lithe, with beautifully moulded limbs. Dwarfs, hunchbacks and misshapen persons are seldom seen in Arabia. Few races of humanity excel the Arab either physically or morally. The Arab derives his sustenance in great measure from his animals and milk. Most of the milk is soured, but this forms the most prominent constitutent of his diet. In fact, under the name sheneena, leben, yoghourt, keffir, koumiss, matzoon and dadhi, soured milks have been used from earliest times very extensively over a large part of central Asia as well as Egypt, Palestine, Arabia, Turkey and the Balkan States. Wherever fermented milks are extensively used as food the physical development of the people is unusually good, and the length of life exceptionally long in many instances.

Almost everyone is familiar with the conclusions of the famous Russian bacteriologist Metchinkoff, that the remarkable number of centenarians among the Bulgarian peasantry was the result of the ingestion of sour milk. Metchinkoff believed that the remarkable results of the regular use of their simple diet was due to the lactic acid producing organism which causes the souring of the milk. Its beneficial effects he attributed to the production of lactic acid by this organism in the intestine, and the inhibition of the growth of the harmful putrefactive organisms which develop there in the residues of protein rich foods. He attributed the early aging of mankind and of animals to the absorption of these toxic products.

It is of more than ordinary interest that the most modern investigations in the field of nutrition, carried out by methods which far surpass those of the past in scientific accuracy, support his observations in a general way as regards the beneficial effects of the diet of the people he observed, but detract from the importance of the organism which the milk contains. It is the correc-

tion of the deficiencies of the types of diet which consist mainly of seed products, tubers or fleshy roots and muscle meats, by the inclusion of the protective food milk, which accomplishes the result of greatly improving health and increasing vigor. The bacteria in the milk are of secondary importance.

It is significant also that the Chinese peoples, while possessing a civilization of great antiquity, have lacked certain qualities which are necessary for the formation of a great nation. They were overrun by successive waves of invaders from the northwest during many centuries. The Chinese peoples have lived during all of their history on a diet derived from cereals, legume seeds, tubers, fleshy roots and meats, together with a liberal addition of green leafy vegetables and some eggs. The widespread practice of sprouting grains preliminary to their use as human foods is justified by the results of modern science. The consumption of a large amount of leafy foods has, I believe, been a factor of the greatest importance in promoting their well-being, for, as has been already mentioned, the leaf of the plant possesses dietary properties very different from those of the seed or other storage organ, and these special properties are just those which are necessary to correct the deficiencies of the seed, tuber, root or muscle meats. It is perhaps significant in this connection that the Chinese have, on their diet in which the leaf was almost the sole protective food, been unable to cope with their sour milk-drinking neighbors to the northwest. The descendants of these waves of invaders still live in China, forming classes which have never been assimilated socially.

Huntington believes that the climate of China is not of a nature which can make possible the development of a highly progressive race. This does not seem justified without taking into account certain other factors which are of importance in this connection. We must agree upon what conditions are essential to the development of a high state of civilization before we can agree upon other points.

In a sparsely settled country, where the care of flocks and herds is the only means of livelihood, as is the case over large areas of Asia, pasturage and water are likely to be greatly prized, and the rights to them sharply contested. Enmity between neighbors, lack of education, and the consequent lack of opportunity to gain ideas from others through reading, lack of incentive to

do anything other than seek the protection of the animals which contribute to the comfort of man, are themselves reasons enough to account for the lack of development of a high state of civilization. The climate need not necessarily be responsible for the result. The energy and aggressiveness of peoples who have dwelt in such regions have been repeatedly exhibited in wars of conquest. They have the physical development and intelligence necessary to form the basis of a civilization, provided the necessary conditions for its growth were existent.

It is necessary, in order that a civilization may develop, that food, shelter, clothing, and other comforts of life shall be obtainable without too great a drain on the physical resources of man. There are several reasons why these conditions are best fulfilled in the cooler parts of the temperate zones where the rainfall is most satisfactory for the growth of farm crops.

One of these conditions is that the winter in these regions destroys certain insects which would otherwise destroy the crops. Certain disease-transmitting organisms, such as the cattle tick and the tsetse-fly, which bear respectively the Texas fever and the sleeping-sickness, do not survive the northern winters, and the population in these regions enjoy freedom from these diseases. Cold winters limit the number of species of weeds and other obnoxious plants, and render the production of useful crops less laborious. These are factors of the greatest importance to agriculture and to the well-being of man.

Wherever insect life, such as the destructive ants of tropical forests or myriads of mosquitoes and other insects, detract from the comfort of man, and where rank vegetation renders futile his efforts at clearing ground for cultivation, and where diseases destroy his domestic animals, and place in his own blood disease-producing organisms which rob him of his vitality and ambition, man must have recourse to power other than his own strength to overcome his obstacles. If we give him the aid of machinery and control over suitable sources of power to free him from his crushing burdens, and the aid of science to free him from the scourge of disease, and a diet which causes him to develop a high state of physical perfection, then we may confidently expect of him any development of mental traits consistent with his heredity. It is the aim of those who direct the great agencies for the promotion of hygiene and public health to bring to the

inhabitants of the tropics these blessings. They have faith that these inhospitable regions can ultimately be made the seats of creditable human societies. Not until all of these problems have been solved will man succeed in the less hospitable parts of the world.

One not infrequently sees in discussions of this nature the statement that in the warm regions of the world, where food is easily obtainable, and little shelter or clothing is necessary to the comfort of man, he sinks into indolence, and remains in a state of ignorance and degeneracy. It is urged that only in such a climate as necessitates exertion and foresight during the summer in order to provide food, shelter and clothing with which to pass a severe winter in comfort, will man develop in a satisfactory way the higher virtues of civilization. The theory has been postulated that energy, aggressiveness, frugality, foresight, inventiveness, solicitude for dependents, respect for property rights and the other virtues of man in his most highly advanced condition, are best fostered in a climate which offers vicissitudes, and requires that the life of the individual shall be a struggle with his environment.

We are also told by others, and it appears logical, that so long as man is forced to spend his days in a struggle for existence he cannot develop his higher mental qualities. It is said that the creation of an aristocratic element in society, whose wants are supplied by the labor and sacrifice of a less fortunate group, establishes the ideal condition for fostering the mental growth which comes from reflection and the study of the ideas of others.

There is doubtless an element of truth in each of these views regarding the conditions under which man will best develop his mental capacities. Leisure is essential to certain types of creative thought. Thought is stimulated profoundly through discussion, reading and observations of the phenomena of nature. It is not yet demonstrated, however, that such creative thought is possible or probable only in temperate regions where there are frequent and pronounced changes in temperature.

Let us now return to the relation of the diet to physical efficiency. We have, I believe, a very important problem to solve in the education of the public in many parts of the United States in the proper selection of food. There are large numbers of people who are living too largely on diets derived almost

exclusively from wheat flour, cornmeal and polished rice, all of which represent the poorest parts of the kernels from which they are manufactured, together with tubers such as the potato and sweet potato, and edible roots such as the beet and turnip, supplemented with muscle cuts of meat. This type of diet is not satisfactory for the nutrition of an animal unless it is supplemented with milk or the leafy vegetables in liberal amounts. Of somewhat lesser value as corrective foods are eggs and the glandular organs of animals. These are, however, very low in calcium and so fail to make good this important fault in the diet.

Early aging and low vitality with consequent susceptibility to disease attend the adherence to an unsatisfactory diet. This conclusion has been forced upon my co-workers and myself as the result of thousands of observations on animals restricted to diets varying in quality and restricted as to source. Variety, palatability and appropriate chemical composition as revealed by the best methods of analysis at our disposal do not necessarily guarantee safety.

There is still some scepticism among thoughtful people as to the importance of diet in its relation to health and disease. This is the natural result of several factors. In the first place we accept as normal such conditions of nutrition as we are accustomed to, until it is demonstrated that a higher standard is easily attainable. We are accustomed to see people old looking at thirty to forty years of age, and do not become impressed by it, even though the occasional preservation of vigor to an advanced age shows us what is possible.

The results of malnutrition are not such as to force themselves on the attention. It is attended by languor but not by pain. The effects of heredity and disease are not infrequently responsible for poor physical development which is scarcely distinguishable from that due to faulty nutrition. Man in different regions lives on diets which are widely different in character, and succeeds sufficiently well to seem to warrant the conclusion that it makes little difference what kind of food he takes, so long as it is wholesome and he has enough. The fallacy of such an assumption becomes apparent in the light of what we now know of the dietary properties of each of the more important natural foodstuffs. We can readily see now that man in different parts of the world is living on all the types of diet on which it has been found

possible to nourish animals, and on no other. In certain places he is attempting to live on diets which cost him his vitality by the time he has reached an age which should find him enjoying the full vigor of middle life. This is the seed, tuber and meat type of diet which has already been described.

Throughout parts of India, China, Japan, the Philippines, eastern South America, Newfoundland and Labrador, beri-beri is common, and is due to faulty diet of a character which we well understand. Those who live almost exclusively on a diet of degerminated seed products, tubers, roots and muscle meats do not miss by a very wide margin developing this disease.

While scurvy has become a relatively rare disease among adults, it is still common among infants which are fed heated milk as their sole food. We now know that the antiscorbutic substance, water-soluble C, is the most unstable complex in the diet, and is readily destroyed by heating to the boiling point of water. It is certainly true that many people who live almost exclusively on cooked foods come very near the point of specific starvation for this particular substance, and narrowly escape developing the disease.

Dr. Goldberger of the Public Health Service has done notable work in the study of the relation of the diet to pellagra in the South. He has pointed out that the diet of the pellagrin consists essentially of degerminated cereal grains, starch, sugar, molasses, sweet potatoes and fat pork. But a very small amount of green leafy vegetables are eaten and practically no milk. He has improved the diets of the inmates of institutions where pellagra was a scourge, and observed that this leads to the eradication of the disease. He and his associates were not able to contract the disease by material from the lesions from pellagrins and with their excreta while the experimenters were living on a satisfactory diet. Further dietary studies made in villages where pellagra was common showed that those families which used liberal amounts of milk very rarely contract the disease, and its incidence is highest in those households where least milk and green vegetables are used as food. The liberal use of the articles which as the result of animal experimentation have been discovered to be corrective in character prevents the occurrence of pellagra. The question as to whether it is a disease due to an infectious agent has not been definitely decided.

It is significant that the incidence of tuberculosis among the general population of a city such as Baltimore is very much higher among the group of people who live almost exclusively on the bread, meat and potato type of diet, and use least milk and green vegetables. If we may safely draw deductions from animal experimentation it appears probable that this diet predisposes these people to infection with the tubercle organism.

Many will not agree with this conclusion, but hold that poor hygienic conditions and opportunity for infection, racial susceptibility and certain trades, are the factors which make this disease common. To this view I would reply that we know that the diabetic patient, whose vitality is lowered both by failure of one of the normal processes of metabolism—the oxidation of sugar—and by faulty diet, as is practically always the case, is extremely susceptible to tuberculosis. The medical profession has for many years recognized that one of the most valuable therapeutic agents in this disease is good nutrition. It is interesting to note that on purely empirical grounds the profession long ago came to the employment of a diet for the tubercular which contained liberal amounts of milk and eggs.

A group of people which is of special interest in connection with the problem of susceptibility to tuberculosis is the non-citizen Indian of to-day. There is no group of people anywhere who are dying more rapidly from tuberculosis. They live out-of-doors all summer, and probably have throughout the year as much fresh air as the average city dweller. They do have abundant opportunity for becoming infected because of their careless association with infected persons, and reckless dissemination of infected sputum. Racial susceptibility has been generally regarded as a satisfactory explanation of the prevalance of tuberculosis among these Indians. It seems to me that there is another and more important factor involved, namely, the unsatisfactory character of their food supply. The non-citizen Indian lives on a reservation and is supported by the government. He has, in general, no interest in agriculture, and does not raise much of his food. His live stock usually consists of horses. He lives on the products which he buys at the agency stores, and these, unfortunately, consist almost wholly of degerminated cereal products, legume seeds, tubers and meats. It seems plausible at least that this diet is an important factor in rendering him susceptible to this rather mildly virulent infection.

In the light of modern nutrition studies we have come to regard as unsatisfactory some of the diets widely used by man. We have demonstrated in certain respects that there is a close parallelism between the history of a poorly nourished animal and a poorly nourished man. Much remains to be learned of the finer details of the dietary habits of man in various parts of the world, and of the health conditions with which these can possibly be correlated. It has seemed, however, that we have succeeded in correlating certain data relating to human nutrition with the results of laboratory studies in a manner which brings to light a most important principle in the selection of foods. If these deductions are sound it is evident one of the great tasks of the general undertaking of raising the standard of public health is the education of the public along two lines. One of these is to extend the use of dairy products, and the other is the cultivation of the habit of eating much more freely of green leafy vegetables than is now the practice anywhere in the United States.

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THE RELATION OF THE U. S. NAVAL OBSERVATORY TO THE NAVY AND SHIPPING INTERESTS OF THE COUNTRY.*

BY

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WHEN a sailor comes into the open he casts an eye aloft and scans the heavens, not only to form an estimate of the seeing and probable weather conditions, but also to note the positions of the heavenly bodies. From this glance he gets an estimate of the course his ship is steering and the possibility of obtaining sights to locate her position on the ocean.

A good navigator, by constantly watching the heavens and consulting his almanac, carries in his head the best times to get his observations of the sun, and just what other heavenly bodies will be in position to be observed at twilight or when the moon is sufficiently bright to light up the horizon distinctly. When cloudy and observations are badly needed, the accomplished seaman knows at once, when a star shows up sufficiently to be observed, what star it is and what use can be made of a snap-shot taken of it with his sextant.

When the navigator gets his observations he notes the conditions under which they are taken and decides mentally on the amount of confidence he will place in them. But when he picks some figures out of his Nautical Almanac with which to work out these observations it never occurs to him to question the accuracy of the tables, nor to question the wireless time signals which he uses to determine his longitude, and which he receives from the Naval Observatory through Arlington by radio practically every day, if he is within three or four thousand miles of Washington.

It is astronomers who furnish the basis of these aids to navigation, and the sailor's confidence in them and their results is complete.

This confidence, while flattering to astronomers and computers, has its drawbacks in that the public is prone to believe that

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the practical results of astronomy are free gifts from heaven, requiring little or no labor on the part of man to keep them up to date.

Astronomy is not only the oldest of sciences, but the father of all sciences, for it was from Astronomy that man first learned of the existence of law in nature which is the basis of scientific progress, and from that knowledge was led to turn his attention to other and nearer phenomena, believing that they, too, must be governed by law.

By watching the heavens through centuries man was gradually impressed with the harmony of motion of the heavenly bodies and the regular recurrence of celestial phenomena.

The risings and settings of the sun, the phases of the moon, the periodic positions of the planets, and the recurrence of the seasons gave food for thought and led to the discovery of rules for the prediction of these phenomena.

Then came Newton's discovery of the universal law of gravitation, which, applied to the observations of the positions of the bodies of the solar system obtained in the past, enabled predictions of their future positions to be made.

Although the laws of gravitation as announced by Newton have stood the test of time, we must not forget the multiplicity of conditions existing because of the number of bodies in space, and the difficulty of obtaining accurate observations.

It is marvellous that observations so accurate can be made from a rotating earth, revolving around the sun, which, with the whole solar system and the so-called fixed stars are themselves rushing through space with great velocities.

But these complications necessitate constant and improving observations, which, in turn, lead to more accurate equations and tables.

The principal practical applications of these tables are in the determination of time, of positions at sea, and in the determination of primary positions on the earth for use in making maps and charts.

These practical applications of astronomy are so essential to a seafaring people that countries having large shipping interests have sooner or later established government observatories to make the fundamental observations, and offices to compute and publish the tables in form for the use of sailors.

Congressional action for instituting a national observatory in this country originated in the earliest movement for establishing a first meridian in the United States, and a report was made by a select committee in the House of Representatives, March 28, 1810, which reported the following resolution: "That it is expedient to make provision by law, authorizing the President of the United States to cause the longitude of the city of Washington from the Observatory at Greenwich to be ascertained with the greatest degree of accuracy, and, for that purpose, to procure the necessary astronomical instruments."

This resolution was laid on the table, and a bill accompanying the report of another select committee was probably destroyed in the burning of the records of the Capitol in 1814. This committee had reported in January, 1813—"that, in their opinion, astronomical observations are highly useful to a navigating and commercial people."

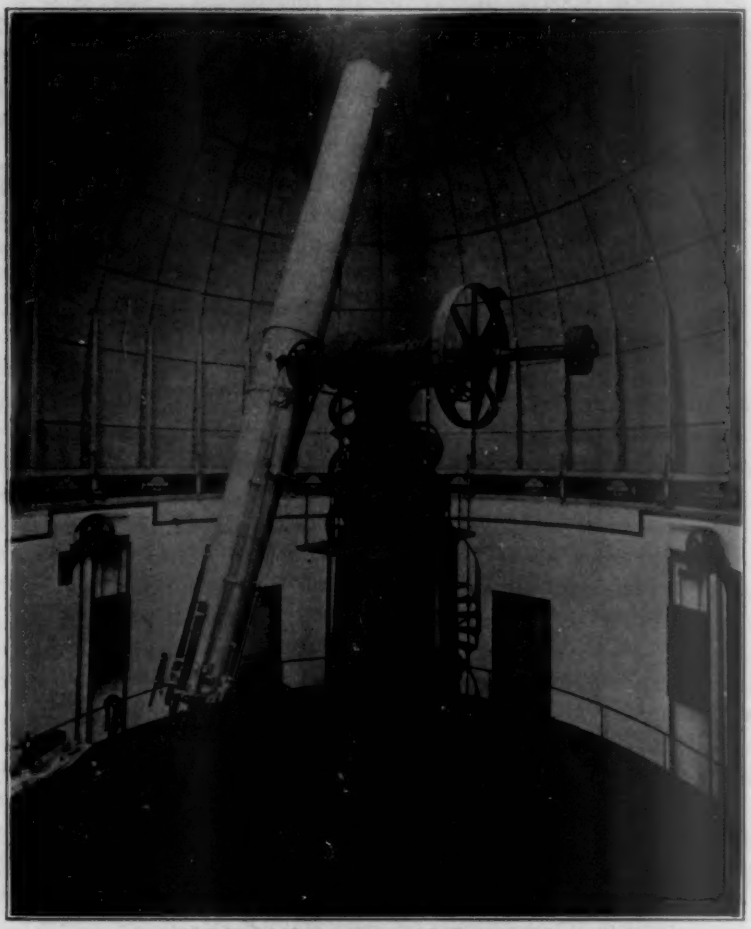
Though numerous scientific reasons were presented to Congress from time to time urging the establishment of a National Observatory, the practical uses of an Astronomical Observatory were not put on record until the Secretary of the Navy, in a letter to the Chairman of the Committee on Naval Affairs of the House of Representatives, dated March, 18, 1830, stated "an Astronomical Observatory "——" would furnish the means of making such observations as would enable astronomers to ascertain or calculate the positions of the heavenly bodies at any time, without being dependent on other nations for the same; and would be, moreover, a fixed point to whose meridian——terrestrial objects may, with certainty, be referred, as far as respects their longitudes," and Commodore John Rodgers, in a letter of the same date to the Secretary, stated as one of the principal objects of an observatory —"to furnish annually our naval and commercial interests with a correct ephemeris, upon the accuracy of which depends so much the safety of our commerce and the lives of our seamen."

In 1830, the Navy established a bureau in Washington for the care of the instruments, charts, etc., of the Navy, and Lieutenant Goldsborough, who had charge, collected the navigation outfits of the Navy there.

About the same time the Navy Commissioners in a letter to the Secretary wrote: "As a matter of national pride and independence, it would be desirable to have an American Nautical Al-

manac adapted to a first meridian of our own— an almanac of this kind would be one of the first fruits of an Observatory, should Congress deem it expedient to establish one."

The necessity for careful rating of the chronometers for the



U. S. Naval Observatory. 26-inch equatorial.

Navy led to the acquisition of a transit instrument to determine the time, and Lieutenant Goldsborough then erected the first astronomical instrument for the Navy at Washington.

Lieutenant Wilkes, who succeeded in charge of the depot in 1833, removed the office to Capitol Hill, and here erected, at his

own expense, an Observatory, sixteen feet square, in which was mounted a five-foot transit loaned by the Coast Survey.

In the spring of 1837 Lieutenant Gilliss was placed in charge of the depot, and, under instructions from Secretary Paulding, commenced a series of astronomical observations of moon culminations, occultations and eclipses, which, with similar observations, to be made by Mr. William C. Bond at Boston, were to be used in determining differences of longitude in connection with the Exploring Expedition to the South Seas under Lieutenant Wilkes.

Gilliss not only succeeded in obtaining some necessary astronomical instruments, but persuaded the Secretary of the Navy to authorize the purchase of magnetic and meteorological instruments and to order additional assistants for the work at the depot.

Under these instructions of the Secretary of the Navy, Lieutenant Gilliss of the United States Navy, himself made most of the astronomical observations and was "the first in the United States who conducted a working observatory, and the first who gave his whole time to practical astronomical work; it was he who first published a volume of observations, first prepared a catalogue of stars, and planned and carried into effect the construction of a working observatory as contrasted with one intended chiefly for purposes of instruction——."

As the observations progressed and the usefulness of the depot to the navigational outfit of the Navy increased the necessity for suitable buildings became more and more apparent, and the practical work already accomplished by Gilliss being gradually brought to the attention of Congress, he succeeded, with the backing of the Navy Commissioners and the Secretary, in getting Congress to pass "an Act to authorize the construction of a depot for charts and instruments of the Navy of the United States," which was approved August 31, 1842.

The report of the Naval Committee which accompanied this bill said, in reference to the value of such a depot: "Since its organization, the Navy has not only been furnished with better instruments and more recent charts, at a greatly less original cost than before, but greater care has been observed in their use, consequent upon the regulations of the Depot, making the masters

of our public vessels directly responsible for each article delivered to them.

"Prior to that time, chronometers were purchased as the wants of a ship or the judgment of a commander dictated, without trial or examination, the only guarantee of its value being the word of the seller. Sextants which were rejected by experienced judges and left as shop-keepers, too frequently found their way into the Navy, through the inability of navy-agents and store-keepers to discriminate between good and bad. A ship rarely went to sea without having the master's store-room half filled with wood compasses, from the prejudice that a light compass could only be obtained by making the bowl of that material. As a necessary consequence, the same set of instruments rarely went to sea two cruises. When the ship returned, they were tumbled into the Navy store, chronometers and all, where they remained till the fitting of a new ship would find them unworthy of further use. This no longer exists; Navy store-keepers are required to render a monthly report of every instrument in their charge; and, as before stated, masters are held directly accountable, so that, with a little additional repair at the end of each cruise, the same set lasts many years. The saving, from this cause alone, is more than the annual cost of the whole establishment."

In reference to Astronomy, the committee say:

"In the summer of 1838, the honorable Secretary of the Navy directed the Superintendent to make a constant series of observations in astronomy, magnetism, and meteorology, ordering an additional number of assistants, and granting authority for the purchase of all necessary instruments."

"We are indebted to other nations for the data which enable our ships to cross the ocean. Not only has the Navy failed to contribute to the common stock from which all our navigators borrow, but our country has never yet published an observation of a celestial body which bore the impress 'by authority'; and it is believed that, until the observations before alluded to in this report, none have ever been directed by the Government which can be considered continuous.

"That great errors exist in the tabulated places of the heavenly bodies, the labors of astronomers of the present day sufficiently prove. Indeed, all who were at all curious in such matters could not have failed to remark how great a difference there was

between the observed and computed times of the last annular eclipse visible in the United States."

"Observatories, though not expensive, cannot prosper in our country until we can obtain rest from the pursuit of mercantile affairs, or their charge is undertaken by the Government. The duties are confining; if properly executed, arduous: and but few are qualified by experience or habits to undertake them. If officers can be found with taste for such duties, an Observatory will give more information to the world, under a military organization, in one year, than under any other direction in two."

"The subject of Magnetism is scarcely less important to the Navy than astronomy. Without a knowledge of the variation of the compass, none but coasting-craft dare venture beyond the precincts of a harbor; yet how few have more than a practical knowledge of the mode of determining its amount. The daily changes of the variation, its extraordinary fluctuations during auroras, the causes, amounts, and modes of correcting the local attraction of ships, and, indeed, the laws governing magnetized bodies generally, are mysteries with which a large portion of the officers have had neither means nor opportunities to become acquainted. Great complaints are made that chronometers perform badly; that ships have been influenced by currents when, if the true cause could be ascertained, it would be found to consist in having steered a wrong course, no allowance being made for local attraction."

"There can be no doubt a large number of the wrecks of shipping occur solely from this cause."

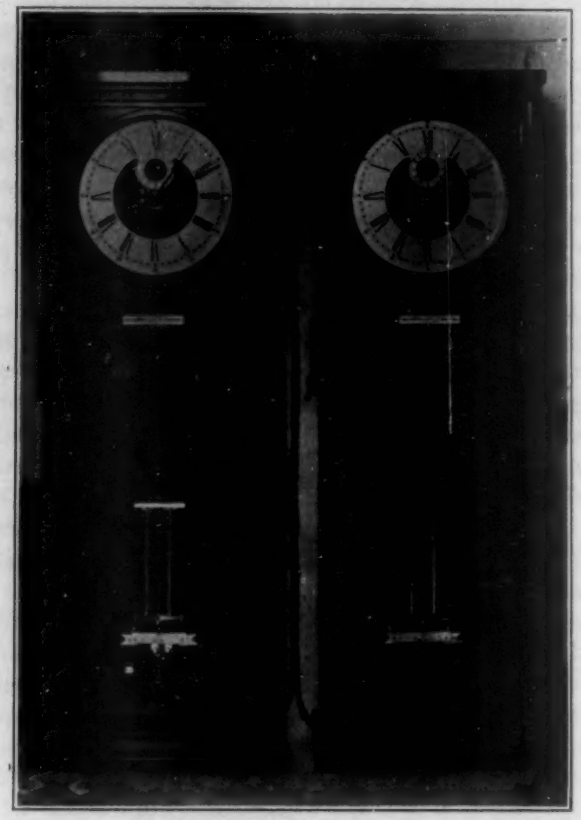
"The magnetic observatories which were established by the European governments two years since, and which have a location in almost every part of the world, were earnestly recommended to us by the learned men of England. Active and extensive co-operation, they say, will be the only mode of setting at rest the conflicting theories of this most important branch of science."

"In regard to Meteorology, if Professor Espy's theory is correct, the day is not distant when we shall be able to calculate the precise point where a storm is raging."

"Meteorological observations are more important at night than by day, because of their scarcity hitherto; and it is scarcely to be expected that amateurs can be found in sufficient numbers to

make all the required observations. Night-watching in stormy weather finds few followers, and we can only hope to obtain the desired information, when those engaged in its pursuit have duty to compel a flagging inclination."

"Deeming an establishment of this description essential to



U. S. Naval Observatory. Transmitting clocks which automatically send out the time signals.

the welfare of the Navy, the committee report the accompanying bill."

A separate report of a select committee on memorials presented by citizens of Philadelphia, New York and Baltimore stated: "——It is incumbent on Congress to provide for the safety of our mariners and of the immense treasures which the enterprise of our merchants throw daily upon the waters.

It is by celestial observations only that charts can be accurately projected——"

The passage of this act in 1842, marks Congressional approval of the Naval Observatory, though it was first called the Depot of Charts and Instruments, and later the Hydrographical Office. In the volume of astronomical observations for 1848, the institution first bears the name of United States Naval Observatory in place of National, by order of the Secretary of the Navy, because the Institution had always been under the control of the Navy Department, and was conducted by Navy Officers, " its reputation is the property of the Navy."

In the act of Congress of March 3, 1849, in appropriating the expenses of the Hydrographical Office it was " Provided that a competent officer of the Navy, not below the grade of lieutenant, be charged with the duty of preparing the Nautical Almanac for publication, and that the Secretary of the Navy may, when, in his opinion, the interests of navigation would be promoted thereby, cause any nautical works, that may, from time to time, be published by the Hydrographical Office, to be sold at cost——."

From and since the Act of Congress of August 5, 1854, specific appropriations have been made for the American Nautical Almanac, and the Revised Statutes, Sec. 436, provided that " The Secretary of the Navy may place the supervision of the Nautical Almanac in charge of any officer or professor of mathematics in the Navy who is competent for that service——."

Lieutenant Matthew Fontaine Maury, to whom Lieutenant Gilliss turned over the new building for the Observatory (which had been completed under his direction), became Superintendent on October 1, 1844, and held that position until he went South in April, 1861, when he was succeeded by Gilliss, who had meanwhile been promoted to a Captaincy in the Navy.

Maury devoted a great deal of his attention to hydrography and interested the Navy and Merchant Commanders in making and preserving " observations on all parts of the ocean upon winds, currents, the barometer, and air and water thermometer, and upon other phenomena calculated to improve navigation." From these reports and the logs of vessels Maury planned and published wind and current charts, and sailing directions on which are still based our present charts, and which have not only materially shortened the passage along the highways by which

our ocean borne commerce passes, but have enabled shipping to avoid locations where large percentages of bad and unfavorable weather conditions are found.

Gilliss, who was a practical astronomer and who had said in his report in 1845, that "he would have regarded his time as misspent to labor so earnestly only to establish a depot of charts and instruments; that his aim was to place an institution under the management of Naval officers, where, in the practical pursuit of the highest known branch of science, they would compel an acknowledgement of abilities hitherto withheld from the service," built up the astronomical staff of the Observatory and acquired new instruments during his Superintendency lasting until his sudden death February 9, 1865.

The Naval Observatory at this time included an Astronomical Observatory, a Hydrographical Office, a Depot of Charts and Instruments, a Meteorological and Magnetic Observatory, and the Superintendent was even required to make a report on interoceanic canals and railroads under the resolution of the United States Senate of March 19, 1866—"Resolved, that the Secretary of the Navy furnish, through a report of the Superintendent of the Naval Observatory, the summit-levels and distances by survey of the various proposed lines for interoceanic canals and railroads between the waters of the Atlantic and Pacific Oceans, as also their relative merits as practicable lines for the construction of a ship canal and especially as relates to Honduras, Tehauntepec, Nicaragua, Panama, and Atrato lines."

These were too diverse activities for a single institution and Congress, by its Act of June 21, 1866, established the United States Hydrographic Office, which then took over the hydrographic work which the Observatory had started.

In 1880 Congress appropriated funds for the purchase of a new site and the preparation of plans for new buildings for the Naval Observatory, and in 1886 the funds for the buildings.

Under these appropriations the site for the present Observatory was carefully selected with a view to its fitness for mounting astronomical instruments and observing with them, and at the same time to be accessible from the city of Washington, and the buildings were carefully designed to suit its needs.

Upon the completion and acceptance of the new buildings on Georgetown Heights the Naval Observatory was moved

there in 1893, and at the same time the Nautical Almanac Office with its library was transferred to and made a department of the Observatory.

In order to give very briefly the reasons for the establishment of the Naval Observatory and the American Nautical Almanac and to afford time in which to tell of the practical assistance they now afford our Navy and Merchant shipping, I have been obliged to leave out practically any account of the work of the many distinguished men who have been connected with their activities.

I must, however, mention, in addition to Gilliss and Maury, the names of Goldsborough, Wilkes, Charles Henry Davis, father and son, John Rodgers, Asaph Hall and Simon Newcomb, of the Navy, and George William Hill, all of whose names are well known to science, but an account of whose work it would take up too much time to attempt to give now.

THE WORK OF THE NAVAL OBSERVATORY.

The first object in acquiring an astronomical instrument for the Depot of Charts and Instruments was for the correct determination of time in order to find the errors and rates of the Navy chronometers.

This service has been continued ever since, and has expanded until now the Naval Observatory not only furnishes accurate time by radio, twice each day, via the Navy radio station at Arlington (and other Navy radio stations when desirable), to vessels anywhere within three or four thousand miles of Washington, and to thousands of private parties who have set up receiving sets throughout the country; but also puts the time signal on any telegraph or telephone wires which are run to the Observatory for the purpose of receiving it.

This has resulted in the Western Union Telegraph Co. supplying Naval Observatory time wherever their wires are run. West of the Rocky Mountains the time signals originate at the Navy Chronometer and Time Station maintained at the Mare Island Navy Yard.

The benefit of standard time signals to the shipping and inland transportation interests of this country, and to watchmakers, jewelers and persons engaged in scientific and other pursuits requiring accurate time, not to mention the general public, is so tremendous that it is difficult to conceive of the confusion and

troubles that would arise were this service discontinued even for a few days. It is often amusing to note the surprise of persons who thought they possessed perfect time keepers, when, on making continuous comparisons with an accurate time signal, they find how much their supposedly accurate watches vary from day to day.

To maintain a time service the Naval Observatory keeps up continuous observations, when weather conditions do not prevent, of the passage of so-called clock stars over the meridian of the Observatory, by means of telescopes set permanently in the meridian and provided with suitable mechanism for accurately determining the time of passage of the stars. These times are compared by means of chronographs with standard clocks whose errors are thus determined whenever a set of stars is observed. The standard clocks are not only the most accurate clocks made, having pendulums of invar, which practically does not expand or contract, but they are secured to solid piers set so far in the earth as to avoid all tremors or vibrations short of those occasioned by earthquakes, and are in a vault where the temperature is maintained constant within one-tenth of a degree Fahrenheit. Each clock is sealed in a glass case and the air partially exhausted so that the resistance of the air and its moisture content is kept constant. They are wound by electricity.

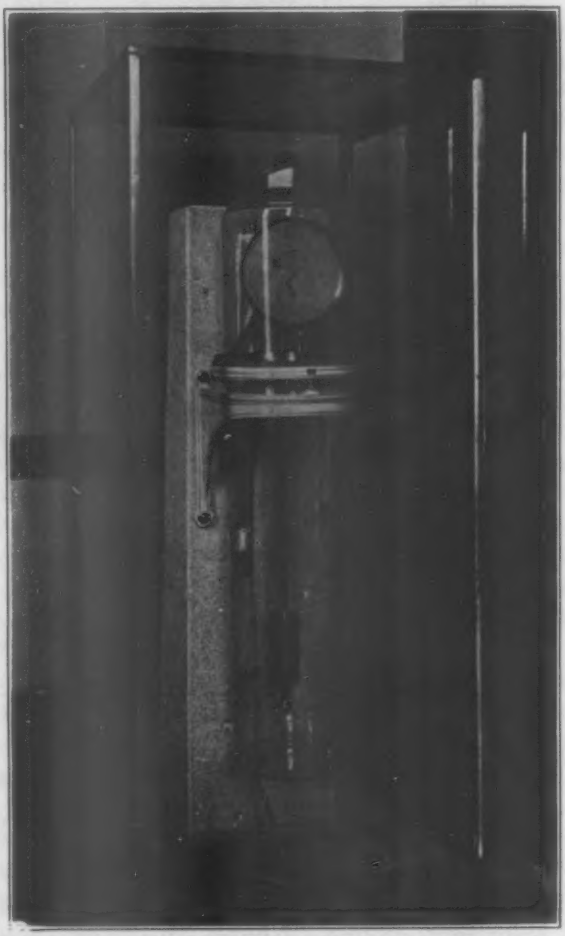
Through electric connections the reading of any one of the three standard clocks is communicated throughout the Observatory and can be compared on chronographs with any other time keeper, star or other observation.

In order to transmit the time signal at noon and 10 P.M., two auxiliary clocks made for the purpose are used, so that having set one of these clocks correctly by comparison with the standard clock shortly before the time for the signal, the clock automatically transmits the signals to as many electric relays as may be desired. The actual time of this signal at different places is checked back from time to time, and the lag, as it is called, at Arlington, is within .01 second of time, and, at Key West, due to the signal being several times relayed by land wire, averages .28 second.

The number of the private radios receiving time was hardly appreciated by the Observatory until they were shut down by the war, and the usefulness of them to the public was emphasized

by the number of immediate requests for permission for their rëestablishment as soon as peace conditions prevailed.

Of course during the war the time signals went out by Navy



U. S. Naval Observatory. Standard clock, three of which are kept at a constant temperature and pressure in an underground vault. These clocks are wound by electricity, and their beats are transmitted by electricity throughout the Observatory so that the vault does not have to be entered unless in case of emergency.

radio and land lines without intermission, and were so necessary to shipping passing through the submarine zone that all other radio work was stopped while the time signal was being sent.

The determination of time by the transit instruments at the

Naval Observatory is only a small part of the work of the Observers on those instruments, and while these results are more immediately apparent, the real work of the instrument is in the determination of the absolute positions of the heavenly bodies.

These positions are ultimately used, not only for time determination, but for navigational and astronomical work.

The astronomical work of the Naval Observatory is planned and executed, "To furnish to the Nautical Almanac Office, as far as possible such observations and such data as may be needed for carrying out the purpose of the law under which the appropriations for that office are made from year to year, which is as follows:

"For——preparing for publication the American Ephemeris and Nautical Almanac and improving the tables of the planets, moon, and stars."

The principal astronomical work of the Observatory is in the field of the astronomy of position as distinguished from astrophysical work, and is the continued maintenance of observations for absolute positions of the fundamental stars and of stars which are to be made fundamental, and in addition the independent determination by observations of the sun, of the position of the ecliptic, and of the equator among the stars, and of the positions of the stars, moon, and planets with reference to the equator and equinoxes.

For carrying out this plan of work the principal instrumental equipment of the Observatory consists of a 9-inch and a 6-inch transit circle, a prime vertical transit instrument, an alt-azimuth, a photographic zenith tube (for the determination of the variation of latitude), a 26-inch and a 12-inch equatorial, a photographic telescope, and a photoheliograph, besides the necessary chronographs and clocks and a clock vault where the standard clocks are kept at a constant temperature. The handling, lighting, and recording of these instruments requires an electrical equipment of motor generators, storage batteries, switchboards, and thermostats and fans, and the mechanical equipment for opening and closing shutters, turning domes and raising the floor of the large equatorial is considerable and requires constant attention. All of these instruments are in actual use now, excepting the prime vertical transit with which a series of observations, continuous for 19 years, has lately been completed.

In order that the work of computing and publishing the observations, without which they are valueless, may keep pace with the observational work there is a small computing division which assists the observers on the instruments in reducing their work; and, incidentally, furnishes a try-out for the young men who first come to the Observatory, and a source from which to draw for observers. Fortunately for Astronomy, it is such an absorbing science that those really devoted to it are almost indifferent to their own material welfare, and work night and day in cold and heat, with sleep and meals at irregular intervals, on a mere pittance. If it were not for this devotion to Astronomy on the part of a few men it would be impossible to get any one to do the work of the Observatory on the salaries allowed by the Government.

These men, because of their knowledge of instruments, optics and glass, were tremendously valuable to the Navy at the outbreak of the war, because of our previous dependence on foreign countries, particularly Germany, for these things, and the necessity for having advisers for the firms undertaking to provide us with glass and instruments made in the United States.

THE NAUTICAL ALMANAC OFFICE

Fortunately Congress in 1912 in authorizing the Secretary of the Navy to arrange for the exchange of data with such foreign almanac offices as he might from time to time deem desirable, with a view to reducing the amount of duplication of work in preparing the different national nautical and astronomical almanacs, and increasing the total data which may be of use to navigators and astronomers available for publication in the American Ephemeris and Nautical Almanac, "Provided, further, that the work of the Nautical Almanac Office during the continuance of any such arrangement shall be conducted so that in case of emergency the entire portion of the work intended for the use of navigators may be computed by the force employed by that office, and without any foreign coöperation whatsoever."

This saving clause enabled the Nautical Almanac to be published as usual, notwithstanding the war, and from 1300 Ephemerides and 1165 Nautical Almanacs for the year 1916, the numbers of the 1918 volume required increased to 1597 copies of the American Ephemeris and 5153 copies of the Nautical Almanac.

These increases were principally due to the increase of our shipping, both naval and mercantile; but the War Department required 845 copies of the American Ephemeris and 535 copies of the Almanac, and of these the American Expeditionary Forces in Europe took 500 copies of the American Ephemeris for strictly military work.

The Departments of Agriculture, Commerce, Interior, and Treasury took 229 copies of the Ephemeris for 1918 and 323 copies of the Almanac.

These publications, besides giving the positions of the sun, moon, planets and stars, give the celestial phenomena for the year, such as eclipses, occulations, etc., tables for the use of navigators and astronomers for converting time and for finding the latitude by an observed altitude of Polaris; and the times of sunrise and sunset and moonrise and moonset, the value of which not only in war but to the average citizen and to light and power companies is obvious.

NAVIGATIONAL INSTRUMENTS

The Naval Observatory is charged with the development, supply, upkeep and inspection of gyro and magnetic compasses, compass equipment, chronometers, clocks, watches, sextants, sounding apparatus, spy glasses, binoculars, and in fact all navigational and meteorological instruments used by the Navy, not only for its surface craft, but for submarines and aircraft.

Prior to the war, the increasing speed and draft of surface vessels, increased gun ranges, and the development of underwater and air craft necessitated new and improved instruments and methods for accurate and rapid navigational and plotting work. The Naval Observatory had encouraged suggestions and the development of methods and instruments, sending out to the service for trial all that gave promise of usefulness.

Special efforts had been made to interest American firms in the manufacture of chronometers, torpedo boat watches and timekeepers in general, of sufficient accuracy to pass the Observatory tests.

Still the number of any one kind of navigational instrument required by the Navy was not great; our merchant marine required but few, and so the manufacture of nautical instruments in this country was confined to a few firms of limited capacity.

Although some chronometers were assembled in this country, the chronometer parts and all torpedo boat watches were manufactured abroad, and practically all optical glass was imported. However, the possibility of American firms undertaking to substitute their products for imported ones had been thoroughly gone into, and where it had not been undertaken it was due to the fact that the American firms did not believe it could be done at a profit, principally because of the limited demand for nautical instruments.

Fortunately the Naval Observatory had encouraged the development of a compass in this country which was not influenced by the magnetic materials of the ships, and a number of these gyro compasses were in use on the dreadnaughts and submarines of our Navy.

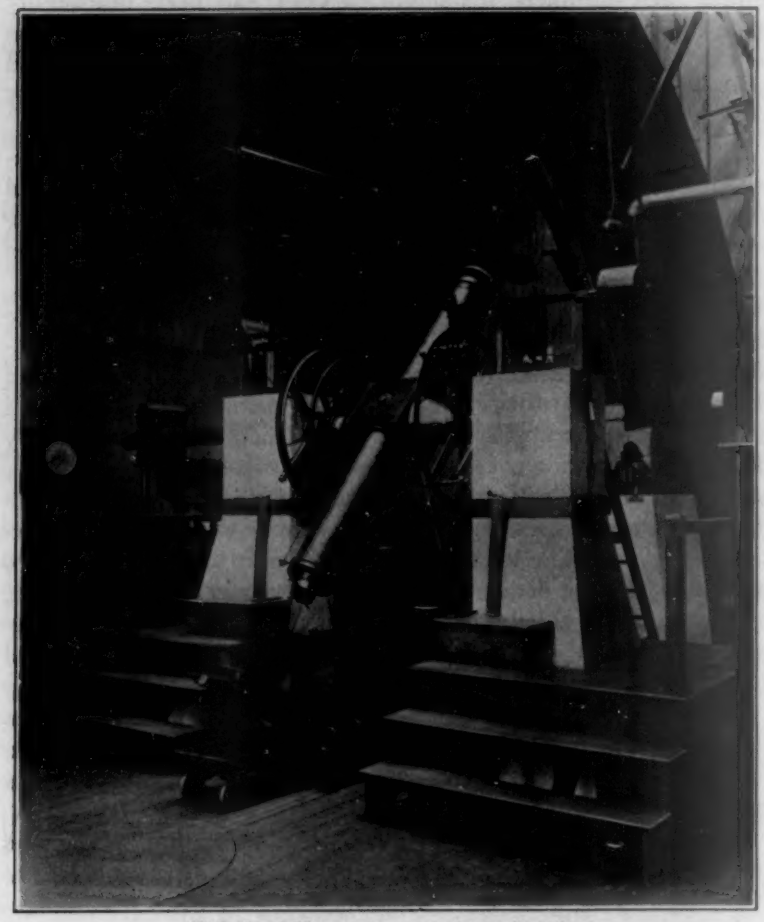
The want of sufficient directive force, the necessity of its installation in an exposed position, the inaccuracies due to movements of large masses of steel (such as turrets and guns), and the practical difficulties in the way of transmitting the readings of the magnetic compass to other points had made it extremely desirable to provide a compass much superior in these respects, at least, to the magnetic compass for battleships, while for the submarine a magnetic compass confined within a steel shell was practically useless. The development of the gyro compass had also been aided by the demand for it, before our entry into the war, by the countries allied against Germany; and as, outside of Germany, America had produced the only gyro compass, the demand for it became very great.

While the Navy had but few aircraft prior to our entry into the war, the necessity for navigational and meteorological instruments for aircraft had been recognized, and the Observatory was encouraging and taking part in their development.

Still all this preliminary work, because of the limited demand in this country, and the small amount of money available by the Navy for development work, furnished only a part of the foundation for the increase required when we entered the war. But attention had been directed to our possible requirements and there were a number of people who had spent considerable thought over them and who were prepared to assist commercial firms in developing into makers of navigational instruments.

A few years before the war the repairing of navigational in-

struments by outside contract was so unsatisfactory, not only in regard to cost but in the time taken and the impractibility of getting the contractors to distinguish between urgent jobs and those that could be delayed, that the Naval Observatory started a repair



U. S. Naval Observatory. 9-inch transit circle.

shop and got an appropriation for furnishing a suitable building in which to locate the shop.

During the war this shop was invaluable not only for the work it turned out, but because the foreman and mechanics were in a position to advise firms undertaking work that was new to them

as to the machinery necessary for their plants and the qualifications of their mechanics.

As the war progressed the Naval Observatory found that it not only had to supply a tremendously enlarged Navy, but vessels taken over from the merchant marine for transports and freight carriers, and finally the vessels built by the Shipping Board.

The latter has helped to prevent waste, loss to contractors and an undue accumulation of a surplus of instruments contracted for before the armistice was signed by taking them over for their shipping which is still being turned out in large numbers.

One of the most urgent needs of shipping plying in the submarine zone was for large numbers of binoculars and other glasses, in order that the lookouts, whose numbers were greatly increased over those required in times of peace, might pick up and distinguish suspicious objects promptly. To meet this demand a call was made on the citizens of the country by the Assistant Secretary of the Navy, Mr. Roosevelt, to loan their glasses, and any navigational instruments they might have, to the Navy for the duration of the war. The response from patriotic citizens was so enthusiastic that 32,000 serviceable pairs of glasses were received, and those that could be were issued and used. They have practically all been returned to the owners with suitable acknowledgment.

THE LIBRARY

One of the features of the Naval Observatory that deserves mention is the library, which is believed to be the most complete mathematical and astronomical library in the world.

The books are not only constantly used by the astronomers of the Observatory but by others engaged in mathematical and astronomical research.

ECLIPSES

In checking up the positions of the sun and moon, solar eclipses furnish a means of verifying their relative positions by marking the times of contact, and for this purpose the Naval Observatory has sent out a number of eclipse expeditions, and at the same time has taken advantage of them to make photographs of the sun's corona and to afford opportunities for spectroscopic observations of it.

DETERMINATIONS OF DIFFERENCES OF LONGITUDE

The Naval Observatory has taken part in or assisted with a number of determinations of differences of longitude; and, in the winter of 1913-14 made a determination of the difference of longitude between Washington and Paris, using radio signals between the Navy Radio Station at Arlington, Virginia, and the Eiffel Tower at Paris.

This work was done in duplicate by observers from the Naval Observatory and by the French, but owing to the war, the computation of the French results was delayed so that the Naval Observatory published the first transatlantic radio determination which was also the first trans-Atlantic determination without intermediate stations.

The distance between Washington and Paris is 3830 miles and radio had never previously been used for longitude determinations at a distance exceeding 960 miles.

When the French results were obtained they were found to agree very closely with those of the Observatory, differing only by two thousandths of a second of time, making the determination of great accuracy.

DISCOVERY

While the principal observational work of the Observatory is in the field of astronomy of position as distinguished from astrophysical work and discovery, the satellites of Mars were discovered by Prof. Asaph Hall of the Navy with the 26-inch Equatorial, and other minor discoveries have been made.

FACILITIES FOR THE PUBLIC

In order to afford the general public a view of the heavens the 12-inch equatorial is given over to their use one evening in each week, cards of admission being issued, and the Astronomer, in charge, besides showing celestial objects, gives a short talk on popular astronomy.

SUMMARY

To sum up, the Naval Observatory performs four principal functions, which are not only absolutely necessary to the Navy and Shipping interests of this country but to the country at large. These functions have been developed by the Navy as the needs for them have arisen, and the plant has been pro-

vided by Congress upon the representations of and work done by the Navy.

These functions are:

(*a*) The furnishing and transmission of daily time signals both by radio and telegraph.

(*b*) The computing and preparing for publication of the American Ephemeris and Nautical Almanac and the Nautical Almanac.

(*c*) The continuous maintenance of observations for absolute positions of the fundamental stars, and the independent determination by observations of the sun, of the position of the ecliptic, and of the equator among the stars, and of the positions of the stars, moon, and planets with reference to the equator and equinoxes in order to furnish data to assist in preparing the American Ephemeris and Nautical Almanac and improving the tables of the planets, moon, and stars. At the same time this department furnishes the observations for determining the time.

(*d*) The development, supply, upkeep and inspection of all navigational instruments for the Navy, which incidentally the Observatory has practically done for the Shipping Board, and has established standards for the growing merchant marine of the country.

The Naval Observatory started the development of the Hydrographic Office; made the first systematic meteorological and magnetic observations at the Capital; and has lately fostered the development, amongst many other instruments, of those necessary for the navigation of submarines and air craft.

Alcohol from Wood. (*Chemical Age*, vol. ii, 1920, 329.)—The production of ethyl alcohol from wood has long been a matter of investigation. The vast amount of wood-waste, for which but little use is made other than for fuel has made the question one of great practical importance. That cellulose, the most characteristic proximate principle of wood, is of the same type as starch and sugar and capable of conversion into a fermentable carbohydrate, dextrose, commonly called glucose, has long been known. In the article from which this abstract is being made, F. W. Kressman gives a great deal of interesting information and presents the practical side of the utilization of wood as a source of ethyl alcohol. As a preliminary he gives some data in regard to

the cost of alcohol from other sources. A bushel of maize yields about 2.4 United States gallons of 95 per cent. alcohol, and a residuum of about 15 pounds of distillers' grains, having a value equal to or even greater than that of the original grain. Molasses yields per gallon rather less than half a gallon of 95 per cent. alcohol. Recently, because of high sugar prices, the sugar content of molasses has been stripped more closely and the yield of alcohol will be diminished.

The production of ethyl alcohol from wood is based upon the hydrolytic effect of dilute acid on cellulose. Kressman gives the cost of grain alcohol before the war as from 10 to 17 cents per gallon, and from molasses somewhat less. These figures seem a little low, but at any rate, present prices are decidedly higher, alcohol from grain costing about 22 cents per gallon and from molasses about 18 cents. Coniferous woods will generally yield from 12 to 20 gallons of 95 per cent. alcohol per ton of dry wood, and coniferous wood-waste about the same amount. The production of commercial alcohol from corn is now practically stopped with corn at $1 per bushel.

The first step in the process of obtaining alcohol from wood is digestion at a pressure of 115 pounds for fifteen minutes in a little less than 2 per cent. of H_2SO_4 per 100 pounds of dry wood, the acid being largely diluted, of course, to avoid carbonization. The cooked wood resembles coffee grounds and the mass contains the sugars. It is transferred to the "diffusion battery," which consists of a series of cylindrical cells so connected that water may be passed through them in rotation. From these cells an extract called "acid juice" is obtained which holds in solution practically all the sugar mixed with other water-soluble ingredients. This liquid is neutralized, either with high-grade limestone or slaked lime. Calcium sulphate is produced which requires about twelve hours for settling. The clear juice is drawn off and cooled to about 88° F., yeast added, and the fermentation carried on in the usual way. The juice must be slightly acid, as ordinary yeasts do not function well in alkaline solutions. By distillation the alcohol is obtained and may be readily refined to the grade of cologne spirit by well-known methods.

Kressman figures that the manufacturing expense, excluding office and sales expense, and package costs, also, unless goods are shipped in tank cars, will be about 21.5 cents per gallon. In some cases, as when coniferous woods are used, turpentine and other by-products may be obtained which will reduce the net cost. The acid juice contains a considerable amount of carbohydrates not ordinarily fermentable, and investigations into these are in progress. Lastly, it is stated that under present conditions the processes can be conducted with profit only in rather large plants.

H. L.

AN AERODYNAMICAL TORSION BALANCE.*

BY

A. F. ZAHM, Ph.D.

Bureau of Construction and Repair, U. S. N.

IT frequently has been found necessary to determine the torque of aerodynamic models about a single axis, or to find the axis of zero torque. To effect this rapidly and accurately the torsion balance described in the following paragraph was developed:

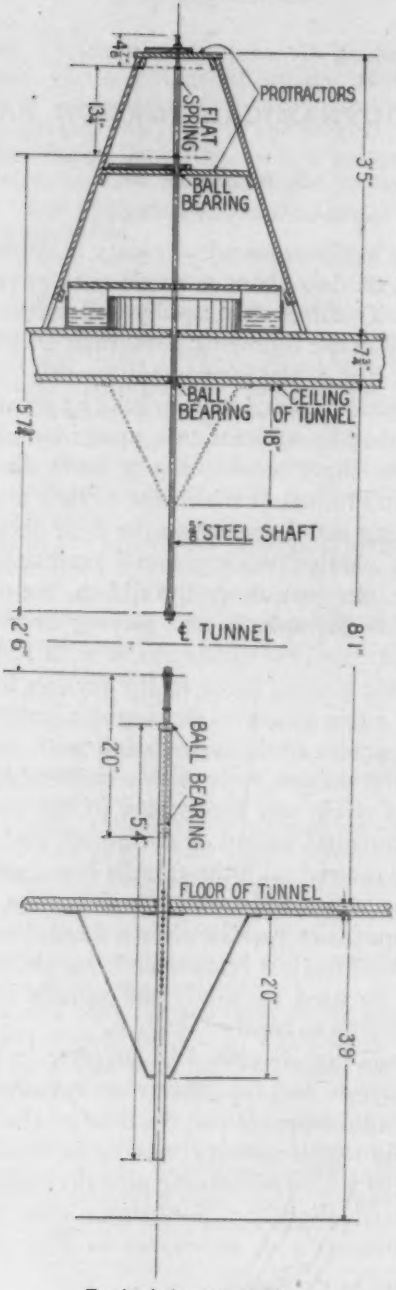
As shown in Fig. 1, the instrument consists of a vertical steel spindle rod supported from a torsion head by means of a thin steel ribbon and steadied in at least two places by ball bearings, the lower end of the shaft terminating a short distance above the centre of the wind tunnel in which the models are to be tested.

The supporting stand resting on the floor above the tunnel, as shown in Fig. 2, carries two horizontal graduated circles coaxial with the spindle, one just above the ribbon, the other just below. A pointer fixed to the spindle and playing over the lower circle shows the angular position of the model with respect to the wind direction; another pointer fixed to the torsion head and playing about the upper circle measures the angular distortion of the steel ribbon by comparison of its orientation with that of the lower pointer. This top pointer rests with considerable friction on the upper graduated circle and forms part of the torsion head from which depends the total weight of the spindle and model. Resting on the floor and coaxial with the spindle is a sheet metal dash-pot containing oil or water and serving to damp the vibration of the torsion rod by means of paddles shown fixed thereto. Supported from the tunnel ceiling is a removable brace shown in dotted outline which can be used to steady the spindle in case of severe lateral forces tending to bend or shake it.

The apparatus just described is complete in itself and useful for a variety of tests, but for other tests requires the supplementary vertical spindle supported on the floor of the tunnel, as shown in Fig. 1. This supplementary spindle is steadied by two ball bearings inside of a coaxial bracing pipe through which it may be raised or lowered slightly. Sometimes also the two spindles form one continuous rod, as shown in Fig. 3. For a larger

* Communicated by the Author.

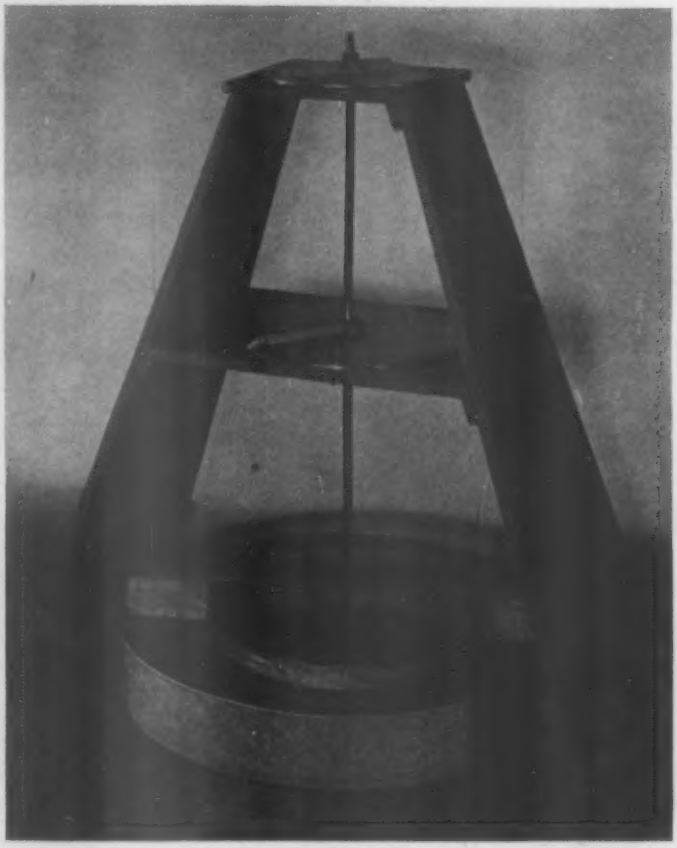
FIG. 1.



Torsion balance assembly.

vertical adjustment the outer pipe itself may be raised or lowered and fixed at any height by means of the pin holes and pin shown in the drawing. It is steadied laterally by a closely fitting plate in the floor of the tunnel and a bearing in the metal bracket shown

FIG. 2.



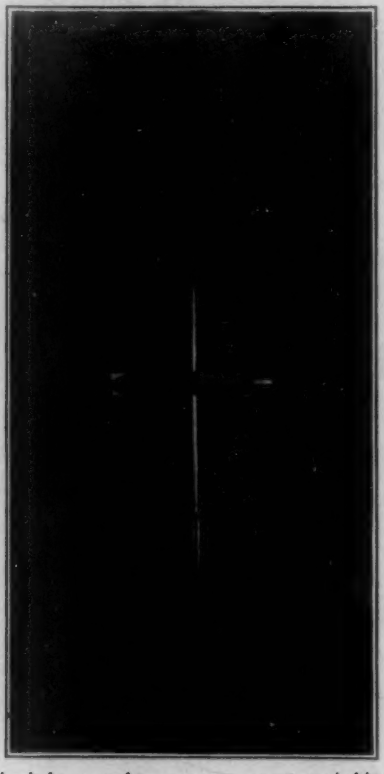
Upper part of torsion balance.

suspended below the floor of the tunnel. When not in use this larger pipe is dropped down so that its top becomes flush with the interior of the tunnel. Both spindles are removed when not in use.

Fig. 4 giving the calibration diagram for the torsion spring, shows that the angular deflections are directly proportional to the

torque, according to Hooke's Law. The calibration was effected by means of suitable weights and a fine cord running about a grooved disc on the lower end of the spindle. Readings were taken both when the spindle carried a model and when unloaded, and were found practically the same for moderate loads. So long

FIG. 3.



Torsion balance used to measure moment on airship hull.

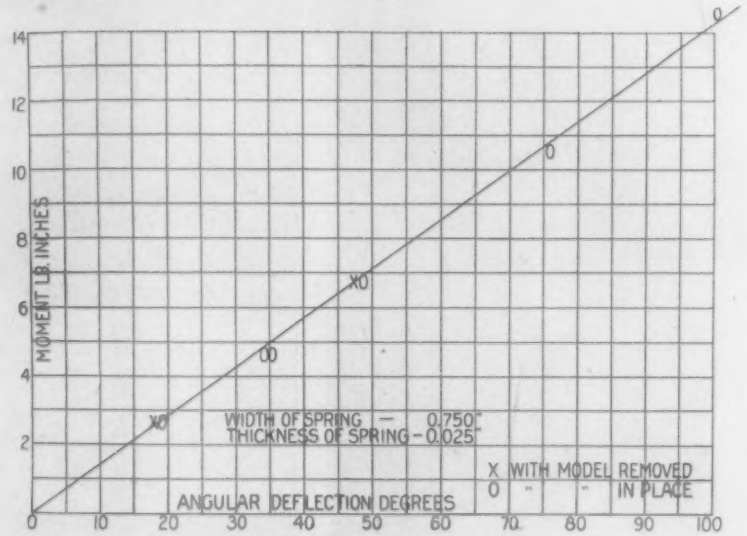
as the axis of the spindle is truly vertical there is no tendency to rotate under gravity even with an eccentric load.

Figs. 3 and 5 illustrate applications of the balance. Fig. 3 shows a Zeppelin balloon model supported on a single vertical spindle and steadied at the upper and lower parts of the tunnel and allowed to assume various angles in yaw. When the model is tested for various angles of pitch it is supported in a similar

manner, but rotated about its own axis 90°. Fig. 5 shows an aerofoil supported at its ends by means of the upper and lower spindles which grip it by means of the forked ends shown, the model itself being capable of displacement up or down stream by means of the narrow strips attached to its ends and clamped by the forks.

In such tests it may be desirable either to determine the axis of no torque or to determine the torque of the model for various

FIG. 4.



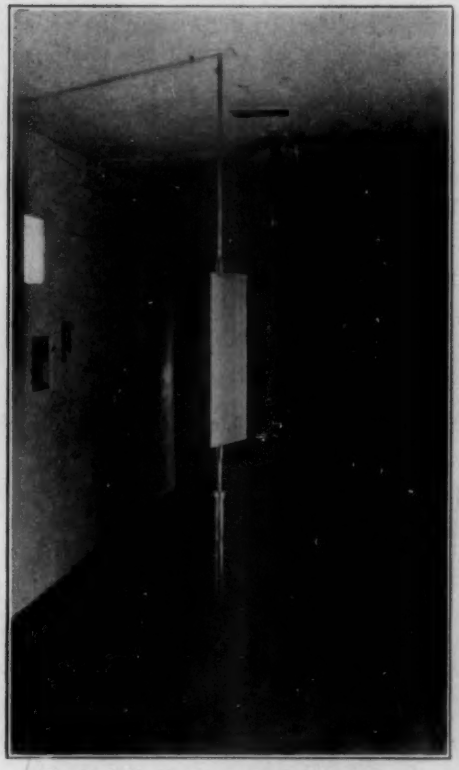
Calibration diagram for spring of torsion balance.

angles of incidence. To determine the axis of no torque the model is allowed to swing freely until it comes to rest in the wind when there is no distortion of the suspension spring, that is, when the torsion head pointer is set exactly parallel with the lower or incidence pointer. To determine the torque of the wind on the model for any particular angle of incidence the torsion pointer is rotated sufficiently to cause the incidence pointer to indicate the chosen angle of incidence. The difference of reading of the two pointers then gives the angular deflection of the ribbon, or the torque by reference to the calibration diagram.

Fig. 6 shows the torsion balance mounted on a wind-tunnel lid, and being transported to its working position on top of the

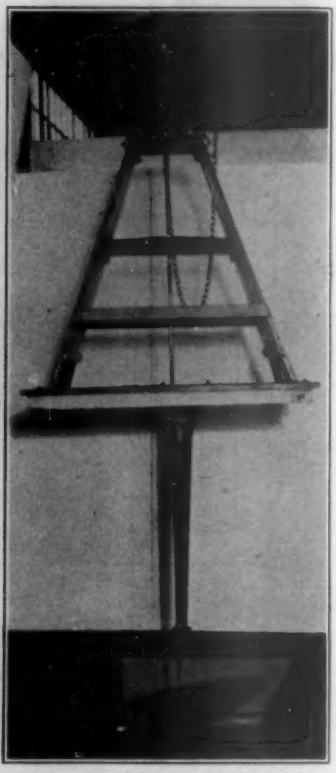
tunnel. When not in use, the instrument and its lid rest on a rack at one side of the laboratory. Models are there attached to the spindle shank and made to swing freely. When the combination is set upon the tunnel, all is ready without further adjustment.

FIG. 5.



Torsion balance used to measure moment on aerofoil.

FIG. 6.



Torsion balance mounted on wind-tunnel lid.

The stream-line hanger shown suspended under the lid carries a ball bearing at its top and bottom to steady the spindle. Two stay wires hold it plumb and prevent trembling. The apparatus is found to be accurate and convenient.

THE PHOTOGRAPHIC RENDERING OF TONE VALUES.

BY

LOYD A. JONES.

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INTRODUCTION.

PHOTOGRAPHY deals with the reproduction of the tone values of the subject in the form of variations of light and shade in the print, each tone in the original subject being represented by a corresponding tone in the finished print, and it is the object of the photographic process to effect a reproduction in which the scale of tones in the finished print corresponds as closely as possible to that of the subject, or in which the scale of tones is modified in a known manner, either from necessity due to the limitations of the process or in order to produce the desired psychological effect. It should be emphasized at this point that the primary object in making a photograph is not in most cases the exact reproduction of the brightness and contrast of the original, but rather the production on a flat surface of variations in reflecting power such that the subjective impression obtained when this surface is viewed under a specified illumination will be as nearly identical as is possible with that produced in the mind of the observer when viewing the objects photographed. In discussing the reproduction, therefore, a careful differentiation should be made between the two phases of the problem, which may for convenience be termed the objective and subjective phases. The former deals with the reproduction of the objective brightness and contrast of the original, such factors being measurable by the usual physical methods of photometry. The latter, dealing with the subjective evaluation of physical brightness and contrast, requires the application of those psycho-physical laws which determine the subjective impression produced by the action of various physical stimuli when applied to an eye in some specified state of sensitiveness or adaptation. This adaptation level is in turn dependent upon the magnitude and time of application of the physical stimuli.

It is proposed in this article to trace the various steps in the photographic process and to explain the factors which affect the objective photographic rendering obtained, the discussion of

the subjective phase being entirely ignored. The factors of importance in tone reproduction may be classified as those dealing with the distribution of light and shade in the subject, the translation of the tones of the subject in the making of the negative including the effect of exposure and development, the scale of printing papers and the translation of the scale of the negative into the scale of the print, and finally the accuracy of the entire reproduction itself, as shown by a direct comparison of the print with the original subject. The last step in this process will be dealt with in a later paper. The present article is intended to form an introduction to the elementary theory of the subject.

THE DISTRIBUTION OF LIGHT AND SHADE IN THE SUBJECT.

When a pictorial representation of a natural object is made upon a flat surface, its form may be represented by areas differing in brightness and color. A painter, for instance, employs both means, while a black and white draughtsman confines himself to differences of brightness, ignoring color. With the exception of special branch of color photography, photography deals only with the reproduction of objects by different gradations of light and shade, and in this article we shall not only ignore the question of reproduction in color but also the fact that natural objects have different colors, and shall consider the problem of their reproduction as if everything consisted of areas differing only in brightness, that is, a series of grays of which black and white are the limiting members. Thus we shall deal with the tone gradations of natural objects but shall ignore the fact that they have also differences of color. The translation of differences of color into monochrome is best considered as a separate branch of photography, which is called "orthochromatic" photography or the photography of colored objects—and it is not proposed to take up this subject in the present article.

Ignoring the question of color, therefore, it is necessary in order to get a precise objective representation of nature to obtain a reproduction as accurate as possible of the whole scale of tones occurring in the scene which is being photographed.

The word "tone" as used in this paper, it should be noted, is practically synonymous with "brightness," being indicative of the intensity factor of the radient flux which, when it falls upon the retina produces the sensation of light. The word "tone" has

been used in some cases to indicate the quality factor (*i.e.*, hue, or saturation), but in the literature of photography its usage has been almost exclusively as indicative of the intensity factor. This precedent seems amply sufficient to warrant its continued use in this sense and hence throughout this paper it should be interpreted as referring to the intensity factor, *i.e.*, brightness. Areas differing in tone, therefore, differ in brightness, or if they are subject to identical illumination they differ in reflecting power and a tone scale consists of a series of areas differing in brightness or in the special case of a flat surface uniformly illuminated of areas differing in deflecting power.

In natural objects these tone gradations are produced by differences both in the reflecting power and in the illumination of the object. The brightness of any portion of a natural object will depend, therefore, upon the illumination falling upon it and also upon its reflecting power. Objects differ very much in reflecting power, the range being from 90 per cent. for white chalk to 1 per cent. for black velvet. The ratio of the highest to the lowest brightness present in any sense may be referred to as the "contrast" of that scene, so that if we have a uniformly illuminated field in which is an area of white chalk reflecting 90 per cent. of the light and also black velvet reflecting only 1 per cent., the contrast will be 90 to 1, or simply 90.

Natural subjects like landscapes may have a greater contrast than this owing to their variation, not only in reflecting power but also in illumination; however, most landscapes have less contrast than the example given. As a result of the measurement of a number of photographic subjects, we may say that a contrast of 4 to 1 would be an extremely short scale or low contrast—a range which would occur in such scenes as the streets of a northern city on a dull day in winter. A scale of 10 to 1 would be a very soft contrast, one of 20 to 1 a soft contrast, while a subject having a scale of 40 to 1 would be considered as a subject of normal contrast. The measurement of contrast in natural subjects such as landscapes can be made by means of a portable illuminometer fitted with a standard lamp and calibrated for the measurement of brightness. By the measurement of the brightness values of a number of natural subjects. the greatest contrast was found in a landscape which included a shadow in a wood and sunlit hills above a river. A total range of 250 to 1 (contrast = 250) was

obtained, the sky being 250 times as bright as the deepest shadow in the wood.

In studio work the contrast is governed largely by the character of the lighting. It was, for example, found by actual measurement that the contrast between a white waist and a black skirt on a sitter, when the lighting was of average quality, was 40 to 1, while the same subject under a softer lighting gave a contrast of 30 to 1. In line lighting the contrast obviously may be very great indeed. In general, in home portraiture, it is difficult to keep the contrast low and at the same time secure lightings pleasing from an artistic standpoint. Measurement showed that typical cases gave a contrast of 65 to 1 on the sitter. When rather dark room furnishings form the background, the contrast between, say, a sitter's waist near the window and the darkest portion of the background may easily be 100 to 1.

THE TRANSLATION OF THE TONES OF THE SUBJECT INTO THE OPACITIES OF THE NEGATIVE.

The purpose of the photographic process is, as has already been mentioned, to reproduce the scale of tones which occurs in the subject photographed as a corresponding scale of tones in the print, and the first step toward accomplishing this is the production of the negative. If this operation does not involve any distortion of the scale of tones, we may say that we have a "technically perfect" negative; and we may define a technically perfect negative as one in which the opacities of the various areas are proportional to the light reflected by the parts of the original subject which they represent.

By the "opacity" of a negative we mean the inverse of the transparency. Thus, if we have light of intensity I falling upon a silver deposit and the deposit transmits an intensity I_1, then we may write

$$\text{Transparency as } T = \frac{I}{I_1}$$

and

$$\text{Opacity, as } O. = \frac{1}{T} = \frac{I_1}{I}$$

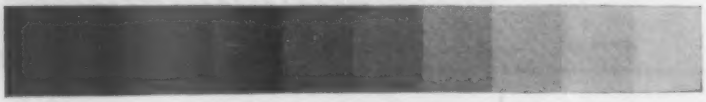
Now, it can be shown experimentally that the mass of silver per unit area is proportional to the logarithm of O, and it is

customary in photographic work to call this quantity D, the density, so that we have

$$D = \log O = \log \frac{I_1}{I}$$

In practical photographic work the logarithms used are common logarithms so that a density of unity will correspond to an opacity of 10, and a deposit having this density will transmit 1/10 of the light. Similarly, a deposit transmitting 1/100 of the light will have a density of 2, and one transmitting 1/1000 of the light a density of 3. It will readily be seen that when we place two deposits over each other we can find their joint density by adding the separate densities. Thus, if we have one deposit transmitting $1/a$ of the light and another $1/b$ of the light, the corresponding densities will be respectively $\log a$ and $\log b$. When the two deposits are superimposed, they will transmit $1/a \times 1/b$, corresponding to a density of $\log a + \log b$. We see, therefore, that if we have a geometrical series of opacities, we shall have an arithmeti-

FIG. 1.



Reproduction of sensitometric strip.

cal series of densities; and therefore a geometrical series of opacities will correspond to an equal addition of silver for each step since the silver is proportional to the density and not to the opacity.

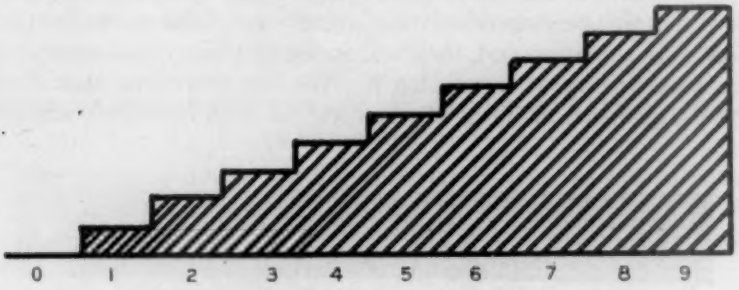
Let us apply this to a photographic example. Take a strip of plate and expose a portion of it to light just long enough to produce on it a barely perceptible blackening after development; then expose another portion for twice the time, another for four times, another for eight times, another for sixteen times, and so on, so that our strip will finally be made up of steps which have received amounts of light in the proportion 1-2-4-8-16-32-64-128-256-512. We might do this by making an instrument which would give different intensities of light in the form of steps and then exposing the plate in this instrument, but in practice it is generally more convenient to give a series of different times

of exposure. Fig. 1 represents the negative we shall get after development.

If the negative correctly represents these different times of exposure in the opacities obtained, the opacities should be in the same numerical ratio as the times of exposure, that is, they should be 1-2-4-8-16-32-64-128-256-512, and since each time the opacity is doubled the density increases by an equal amount, the density (that is, the amount of silver) would be in the proportion 0-1-2-3-4-5-6-7-8-9, as shown in the following table:

Exposures	1	2	4	8	16	32	64	128	256	512
Opacities	1	2	4	8	16	32	64	128	256	512
Densities	0	1	2	3	4	5	6	7	8	9

FIG. 2.



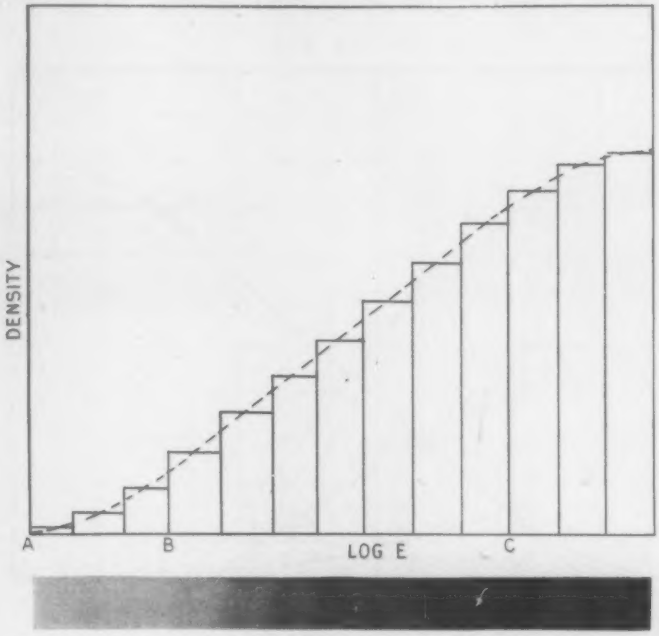
Diagrammatic cross section through ideal negative.

that is, if we cut an imaginary section through the negative so as to show the height of the deposit of silver, it would look as shown in Fig. 2.

If we actually try this experiment upon a plate, however, we find that the densities do not show this equal rise with exposure throughout the entire scale. What we get instead is shown in Fig. 3, and this diagram requires careful study. Starting at *A* and proceeding to *B*, we notice that at the beginning, in the lower exposures, the steps are marked by a gradually *increasing* rise. A negative, the gradations of which fall in this period, will yield prints in which an increasing contrast is shown between tones of uniform increase of brightness; that is to say, the negative will appear what we term "under-exposed." From this period at *B* we pass imperceptibly into the period where the densities show uniform rise for each equal increase of exposure, and here we have our technically perfect negative, that is, one in which

the opacities are exactly proportional to the light intensities of the subject. This is termed the "period of correct exposure," and only through this period of the curve, where the opacities are directly proportional to the exposures and where the densities show an equal increase each time the exposure is doubled, can we get, in the negative, a perfect rendering of the original subject. From the point *C* onwards we have a gradually diminishing in-

FIG. 3.

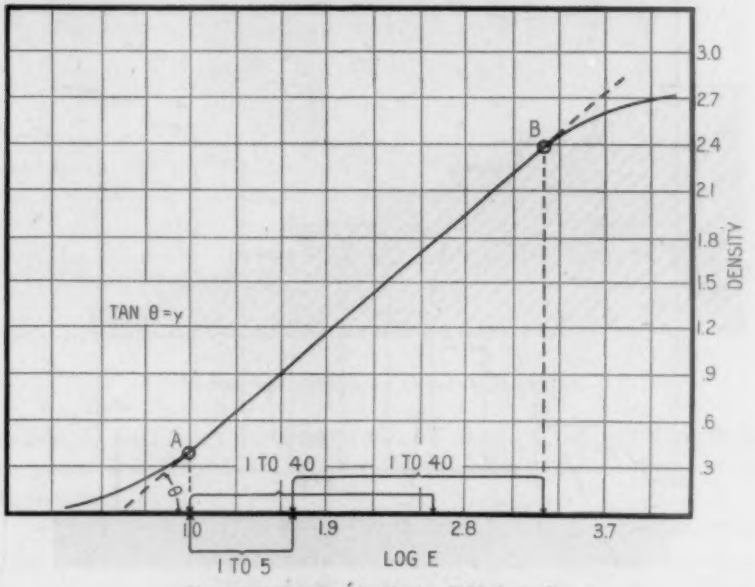


Sensitometric strip with resulting density curves.

crease of density with exposure until finally the increase of density with further exposure becomes imperceptible. This period is the period of over-exposure, in which the opacities of the negative fail to respond to increasing amounts of exposure, and the correctness of rendering is again lost. It will be seen from this curve at once, then, that only through the period of correct exposure, where equal increases of exposure are represented by equal rises in density can the tones of the original subject be correctly reproduced in the negative.

This curve showing the relation between the density and the log exposure was given originally by Hurter and Driffield in their classic paper on photographic theory.* The curve was termed by them the "characteristic curve," and the form in which it is usually plotted is shown in Fig. 4. As has already been stated, throughout the period of correct exposure the curve is represented by a straight line. If this straight line is produced to cut the exposure axis, it will meet it at a point log i, where i was termed by Hurter and Driffield the "inertia" of the sensitive

FIG. 4.



Characteristic curve showing available latitude.

material, the value being stated in exposure units so that the intercept of the straight line on the exposure axis is measured as the logarithm of the inertia.

The tangent of the angle which the straight line makes with the exposure axis was called by Hurter and Driffield the "development factor" and is signified by γ. During development the inertia point i does not change, as is shown in Fig. 5, but the steepness of the straight-line portion of the curve increases

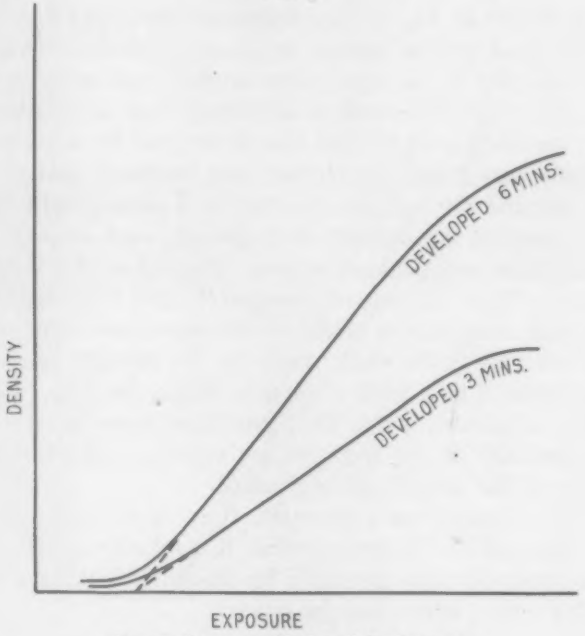
* F. Hurter and V. C. Driffield, *Jour. Soc. Chem. Ind.*, May, 1890.

so that gamma depends upon the time of development. The equation for the straight-line portion of the characteristic curve is therefore

$$D = \gamma (\log E - \log i)$$

A scale of tone values will be proportionately reproduced in a negative in so far, and only in so far, as it falls within the straight-line region of this curve, the length of the straight-line

FIG. 5.



Change of gamma with time of development.

portion being termed the " latitude " of the material. This property varies very much in different negative-making materials, being least in contrasty process plates and greatest in long scale portrait plates. The total range of exposures falling on the straight-line portion of the longest scale plates may be as great as 1 to 200, and a subject having a scale of 1 to 40 may therefore be placed within the straight-line portion of the negative with exposures varying from 1 to 5, this being the effective latitude of exposure available on such a material without any effect being

produced upon the accuracy of the tone rendering. The conditions for correct translation of the tones of the subject into corresponding opacities in the negative are therefore:

1. That the negative material has a long straight-line portion to its curve.

2. That the exposure is such that the scale of intensities of the subject falls entirely within this straight-line portion.

THE EFFECT OF DEVELOPMENT UPON THE SCALE OF THE NEGATIVE.

As is shown in Fig. 5, two negatives developed for different times will give curves similar in shape with their straight-line portions meeting at the same point on the exposure axis, but the slope of the two curves will be different, that developed for the longer time being steeper than that developed for a shorter time. This result was found by Hurter and Driffield, and it follows from it that the ratio of the densities in a photographic negative remains constant throughout development, each density increasing to the same proportional extent. The value of I is therefore a measure of the contrast of a negative, and it is customary to express such contrasts in terms of the numerical value of γ, *i.e.*, of tan θ where θ is the angle made by the straight line with the exposure axis. Thus, with γ equal to unity, the rate of increase of density is proportional to the logarithmic increase of exposure, and the opacities of the negative are exactly proportional to the intensities of the subject photographed.

During development γ increases from O to a limiting value γ_∞. The rise of γ is exponential, the velocity of development being represented approximately by the equation for a reaction of the first order, which may be written

$$K = \frac{1}{t} \log \frac{\gamma_\infty}{\gamma_\infty - \gamma}$$

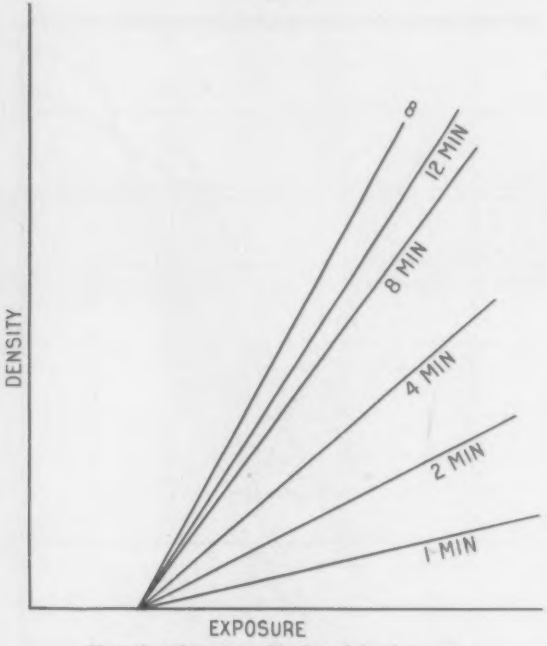
or, in the exponential form

$$\gamma = \gamma_\infty (1 - e^{-kt}$$

Figs. 6 and 7 show the calculated γ's for a material having a γ_∞ of 2 0 and a value of k of .100. The value of γ_∞ depends upon the photographic material itself. High speed portrait plates have low values since no portrait requires development to a γ exceeding unity. Plates used for landscape work and commercial photography have higher values and will give greater contrast on develop-

ment. They develop more quickly and easily and give contrasts exceeding the maximum to which the fast materials can be pushed, while the greatest contrast of all is obtained with the special, low-speed emulsions made for process work, where every effort is made to get the greatest possible contrast in order to obtain clear lines on a completely opaque field. The maximum contrast given by process plates is frequently as high as 4, which

FIG. 6.



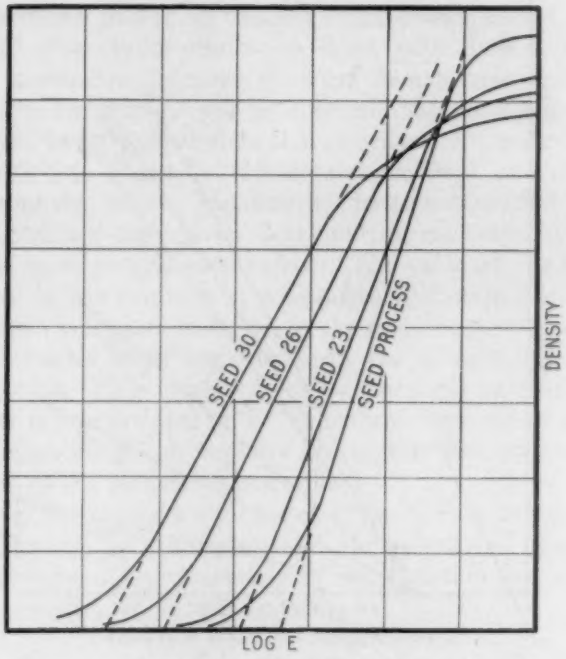
Variation of gamma with time of development.

means that, if we have two tones in the original subject, one of which is twice as bright as the other, the part representing the higher tone in the negative will transmit only one-eighth of the light of that corresponding to the lower tone. Fig. 7 shows the curves of four different plates of the same manufacture, each having been developed to the maximum contrast possible. The notable differences in sentitiveness, scale, and contrast are very well shown in this figure.

The contrast to which a negative should be developed will,

of course, depend upon the contrast of the original subject. Suppose that we have a range of brightness values from 1 to 100 in our subject. If we develop the negative to a contrast of unity, and if the length of the straight line—representing the quality of the material—and the exposure are such that we get exact reproduction of the entire scale of the subject in the negative, we shall have a negative in which the ratio of the highest to the lowest

FIG. 7.

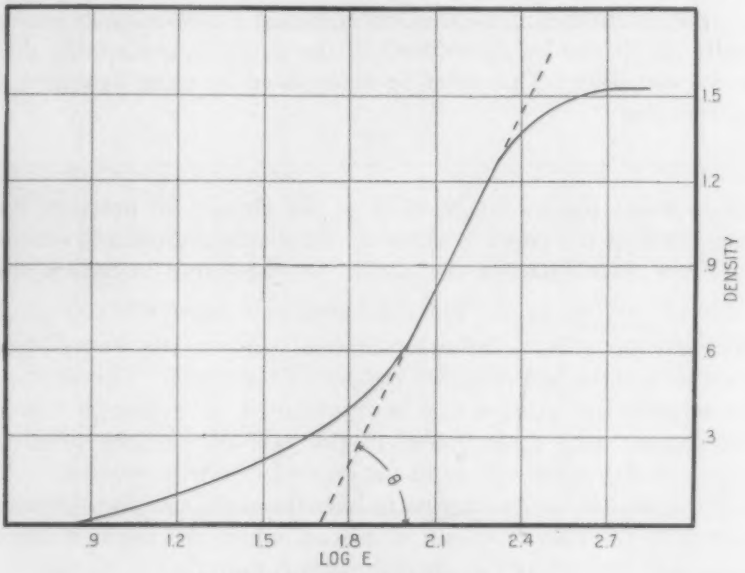


Characteristic curves of typical plates.

transmission is the same as that of the highest to the lowest brightness of the subject; namely, 1 to 100. If this scale of negative densities is too great for printing on the papers which are available, we can reduce the scale by lowering the contrast of the negative; that is, by developing the negative for less time, which will reduce each density in the same proportion. On the other hand, in the case of "flat" subjects (low contrast) we can lengthen the time of development, thus increasing the resulting

contrast in the negative. Provided that the contrast of the subject is not too great for the latitude of the negative material and that the exposure is such that the tone scale of the subject falls on the straight-line portion of the curve, development to a gamma of unity will make the scale of intensities (*i.e.*, transmission values) of the negative the exact inverse of the scale of intensities (brightness values) of the subject.

FIG. 8.



Characteristic curve of developing-out paper.

PRINTING PAPER.

The characteristic curve of a printing paper can be determined in exactly the same way as that of a negative-making material except that instead of measuring the light transmitted by the various densities, the light reflected from the various portions of the print must be measured. We thus get a series of reflection densities from the paper corresponding to the transmission densities of the negative. The characteristic curve of a paper will be of the form shown in Fig. 8.

It will be seen that the following constants will be of importance in specifying the properties of photographic paper. The

maximum black; that is, the reflecting power of the darkest (minimum reflecting power) deposit that can be obtained on the paper with full development and exposure. Such a deposit may reflect from 2 per cent. to 10 per cent. of the incident light, the average value of the maximum black for photographic papers being about 5 per cent., corresponding to a reflection density of 1.30. Matte papers will give a reading from 1.10 up to 1.35; semi-matte papers from 1.35 to 1.50; and glossy papers from 1.50 to 1.8. The total scale of the paper may be defined as the range of light intensities, expressed either in log exposure or exposure units, which can be reproduced by the paper as perceptibly different densities. This must be determined by some assumption of the value

$$\frac{dD}{d \log E}$$

which limits the useful gradient of the curve. In practice, the total scale of the paper is taken as the distance measured on the exposure axis between the points on the curve at which the value of $\frac{dD}{d \log E}$ is .2. The total scale of a paper will consist of three distinct parts—the under-exposed portion, the straight-line portion, and the over-exposed portion of the curve. The slope of the straight-line portion can be represented by γ, though γ does not change with development in the case of gaslight printing papers in the same way as in the case of negative materials. It is quite possible for two papers to have the same scale but different values of γ. This is shown in Fig. 9, where the paper marked *B* has a much steeper straight-line portion than the one marked *A*, but both have the same total scale value.

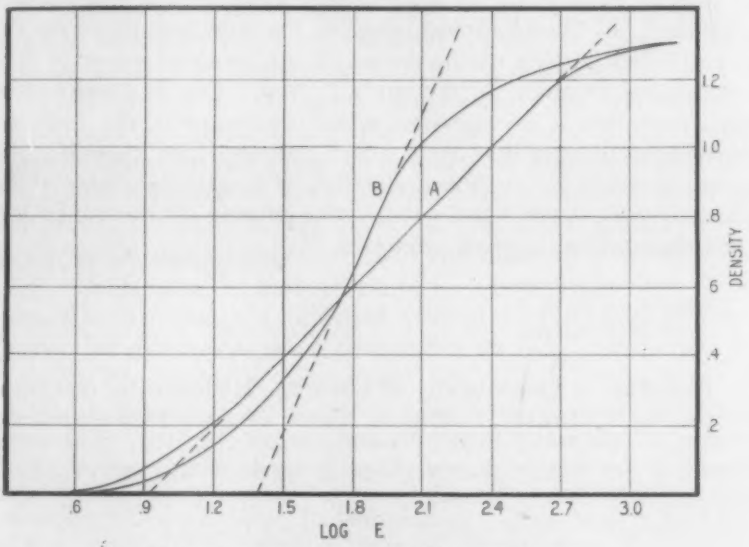
In choosing a paper for printing from a given negative, it is obvious that if all different densities in the negative are to be rendered as different densities in the print, the exposure scale of the paper must be at least as great as the difference between the maximum density and the minimum density of the negative. If the maximum density of a negative is 1.7 and the minimum density is .4, the logarithmic scale of the paper must be 1.3, or the scale in exposure units must be 20.

In order that papers may be suitable for various types of negatives, they are made with different scales. Thus, papers for amateur negatives, which tend to flatness, are made with

fairly short scales ranging from 20 exposure units down to 5 in the most contrasty paper made, this being suitable only for negatives with a maximum density difference of .7. On the other hand, the scales of papers intended for portraiture, where the negatives are of good quality and have a long scale of densities, are of the order of 40 to 60.

Exact reproduction of the tone values of the negative and consequently of the subject upon the printing paper can be accom-

FIG. 9.



Illustrating equality in total scale of different papers.

plished only through the straight-line portion of the characteristic curve of the printing paper. Owing to the narrow range of reflecting powers available in prints, however, it is almost imperative to use the entire density scale of the paper and consequently to sacrifice truth of rendering at both ends of the scale, since the straight-line portion of the curve of the printing paper covers only a small part of the total scale. The ratio of the straight-line portion of the total scale is termed the "rendering power" of a printing paper, and this ratio measures the capacity of a paper to give correct proportional reproduction of a scale of exposures. Thus, a paper that is perfect in rendering power would throughout

its total scale produce densities proportional to the exposure. It is not necessary for correct, proportional rendering for the slope of the straight-line portion to be unity, for as long as the line is straight, the rendering is proportional, but a change in the value of γ will produce a change in the proportionality factor, that is, in the contrast. It is obviously impossible with photographic papers to obtain an exact reproduction of a scale of tones extending over a very wide range such as exists in practical work. As has been shown, it is possible to reproduce exactly in the negative a range of brightness of from 1 to 40 and still retain a latitude of exposure of 1 to 5, but the maximum range of the reflecting power in the straight-line portion of the curve of any printing paper is very limited and in order to reproduce a range of tones greater than this maximum it is necessary either to compress the scale by developing the negative to a lower gamma, thus changing the proportionality factor of reproduction, or to utilize portions of the characteristic curve lying outside the latitude of the paper and thus depart from correct rendering.

EASTMAN KODAK COMPANY,
ROCHESTER, N. Y.
December, 1919.

Pollution of Deep Wells at Lansing, Michigan, is described by the State Sanitary Engineer, MAJOR EDWARD D. RICH, in the *American Journal of Public Health,* 1920, x, 147–151. The water supply of Lansing is derived from 32 wells which vary in depth from 350 to 400 feet. The water became contaminated with polluted ground water; an epidemic of dysentery and typhoid resulted; and chlorination became necessary to provide a safe supply. When such wells are constructed in the best possible manner, three avenues still exist by which dangerous pollution may suddenly occur. The joints and piping may deteriorate. Pumping in excess of the normal capacity of the wells tends to open the texture of sandstones and to enlarge any fissures which may be present; entrance of surface water seepage is thereby facilitated. Another well may be sunk to the same water-bearing stratum in the search for water, oil, or salt, then be abandoned without plugging sufficiently tight to exclude surface water. The conclusion is drawn that deep wells situated in the midst of urban development require the same watchful care that would be given to a shallow well supply or to a surface supply known to be subject to periodical contamination. This care is a requisite even though the depth and mode of construction of the wells would seem to render it unnecessary. J. S. H.

FLOTATION.*

BY

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FLOTATION is a process of mechanical concentration of ores. Its significance and its unique position in the metallurgical art can be best understood by considering, first, the state of the art of mechanical concentration prior to its introduction.

The process of getting to manufacturers the metals, copper, zinc, lead, etc., on which their industries are based is a complex one. These metals occur in Nature as minerals, usually in chemical combination with sulphur. Such minerals are called *sulphides*. Sulphides are found in the earth associated with various worthless minerals, quartz and other silicates, limestone, etc., which form the bulk of the rocks we see every day. If this association contains a sufficient amount of the metal to permit economic extraction, the rock is called an *ore*. The first step in getting the metals is mining the ore. As it comes from the ground, however, most ore contains such a large amount of worthless material, called *gangue*, that before it can be economically treated by chemical means to extract the metals themselves it must usually be treated by some mechanical means to separate the valuable mineral from the worthless rock. This mechanical treatment is called *concentration*. It divides the ore into two parts, a *concentrate*, much smaller in bulk and higher in metal content than the original ore, and a *tailing*, which contains the bulk of the gangue with but a small portion of the valuable mineral. The concentrate goes to the smelter for chemical treatment, which drives off sulphur and associated impurities and gives more or less pure metal. The tailing goes to waste.

The purpose of concentration is, of course, to cut down the cost of the subsequent chemical treatment. There are three measures of the efficiency of concentration: (1) *Grade of the*

* Presented at a meeting of the Mining and Metallurgical Section held Thursday, April 11, 1918.

concentrate, by which is meant the percentage of metal contained in the concentrate; (2) *ratio of concentration,* which is defined as the ratio of the weight of original ore to the weight of concentrate produced from it; and (3) *percentage of recovery,* which is defined as one hundred times the quotient obtained by dividing the weight of metal contained in the concentrate from a given lot of ore by the weight of metal in the lot. When grade of concentrate, ratio of concentration, and recovery are high, concentration is efficient, and *vice versa.*

Concentration comprises two operations: (1) Severing the valuable mineral from the worthless rock with which it occurs associated and (2) subsequently separating the grains of valuable constituent from admixed grains of worthless rock.

Gravity concentration, by means of which the bulk of copper-, lead-, and zinc-bearing minerals have been separated from the worthless part of their ores in the past, consists in subjecting the ground mixture of valuable mineral and gangue to two supplementary processes, *viz.,* sizing and sorting. Either may precede the other. Sizing may be done by screens or by thin films of water flowing over inclined planes. Sorting is done in the mills by various mechanical modifications of the sorting action of streams, ponds, and quicksands. If a mixture of heavy sulphide and light gangue particles of the same size is introduced into an upward current of water of the proper velocity, the lighter part will be floated away and the heavy part will sink to the bottom. Or if a mixture of particles of the same materials with equal settling velocities—*i.e.,* water-sorted—is subjected to sizing, the large grains of light mineral will be separated from the small grains of heavy mineral. The treatment of an ore by these supplementary processes is, in its essentials, *gravity concentration.*

The bugbear of gravity concentration is the saving of the valuable mineral in the *slimes;* that is, in the very finely divided material. On such material it is difficult, by gravity concentration, to make recoveries exceeding 30 to 50 per cent. of the total mineral value present; the concentrate is low-grade and the ratio of concentration is low. That is, the concentration is inefficient and the subsequent smelting very expensive.

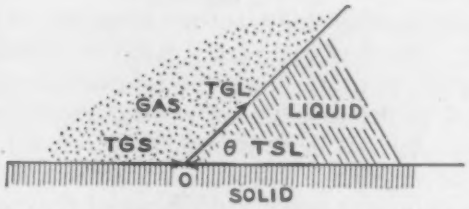
Flotation operates at its best on these slimes, and can make recoveries ranging from 85 to 98 per cent. of the total metallic

content of the ore, the grade of the concentrate being many times better than that of the concentrate made on the same class of material by gravity concentration methods.

Flotation is concentration upside-down. The same sulphide minerals of lead, zinc, and copper which were separated from the worthless rock in gravity concentration by causing them to sink away are, in flotation, caused to float while the particles of gangue sink. Separation is thus effected; this, notwithstanding the fact that the valuable minerals are generally much heavier than the associated gangue.

A simple experiment illustrating flotation is described below. The materials and apparatus necessary are: an agitator, a square

FIG. 1.



Enlarged view of forces at three-phase contact, as in case of floating needle.

jar, water, ore ground to pass a screen with an aperture of 0.15 to 0.20 mm., oil and concentrated sulphuric acid. The agitator is preferably of the type known as a bar- or soda fountain-mixer, having a stirring shaft extending downward from a small vertical motor; but a high-speed egg beater will serve the purpose. For most ores a steam-distilled pine oil or a coal-tar creosote or a mixture of either or both with a petroleum product will serve. Having the materials, mix the ore and water in the proportions one of ore to four of water by weight in such quantity as to fill the jar two-thirds full. Add a few drops of oil and agitate violently for two or three minutes. Allow the mixture to come to rest. If no froth rises, add more oil and repeat the agitation. If the froth contains much gangue, the addition of from 5 to 25 pounds of sulphuric acid per ton of solid will often serve to clean it up. Several trials will usually be necessary before a satisfactory oil mixture is found.

A test run as just described is qualitative only. For quantitative work the Janney laboratory machine is by far the best

yet devised. This works with a charge of slightly more than one pound of ore, discharges froth continually, and circulates the pulp (wet ore) through the machine again and again in order to allow each particle of sulphide many chances to float.

HISTORICAL.

Oil for collecting metals is mentioned by Herodotus in his story of the virgins who collected gold from the mud of a lake by means of feathers daubed with pitch. The process seems, however, either not to have been commercially successful or to have been kept, so far as the mining public was concerned, a secret process, for in 1860 an inventor came forth with the idea of the preferential affinity of oil for metallic minerals as entirely new. The patent literature on the subject from that date to the present is an interesting study, but too involved for presentation in this paper. The first commercial flotation installation in the United States was in 1911. The present importance of the process may be judged by the fact that with such a recent beginning the tonnage treated by this method last year exceeded that treated by gravity concentration.

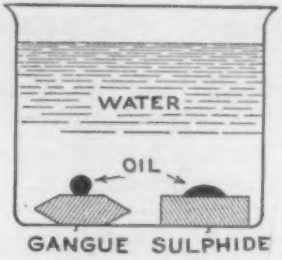
There are at present two distinct types of flotation processes: (1) *Skin flotation;* (2) *froth flotation.* The first is an application of the favorite parlor trick of floating a "greased needle" (see Figs. 3 and 4). It depends upon the greater reluctance of water to wet minerals of metallic lustre than those of vitreous or earthy lustre in the presence of air. It is a manifestation of the force residing in the surfaces of contact between any two dissimilar phases in Nature. This force is called *surface tension.* It causes the substance at the boundary between the phases to act somewhat as a stretched skin would act to resist rupture. Just as the steel needle floats when it is carefully laid on the surface of plain water and as a similar needle of glass will not float, so if a mixture of minerals of metallic and non-metallic lustre is gently brought onto the surface of still water, the mineral with metallic lustre will float, the other will sink and a separation thus be effected. The process is not, however, efficient nor of wide application.

The two essentials to successful froth flotation are (1) the selection of the valuable mineral from the gangue and (2) the formation of a froth of sufficient stability to allow for its separa-

tion from the bulk of the pulp. What actually happens in the selection of the valuable metallic mineral from the gangue is illustrated in Fig. 2. In this figure are shown drops of oil clinging to particles of sulphide and gangue immersed in a body of water. The drawing is a diagrammatic representation of a simple experiment. The particles of sulphide and gangue, after immersion in the water, are touched with a capillary pipette containing oil and some of the oil is forced out. It quickly spreads on the surface of the sulphide and draws together in spherical shape at the surface of the gangue particle.

The explanation of this phenomenon involves (1) the conception of potential energy at all contacts of dissimilar physical phases, and (2) the law of least potential energy.

FIG. 2.



The first conception is stated as follows: At the contact of any two unlike, distinct physical phases there exists a certain definite amount of energy per unit of area. This conception has been proved for any number of contacts. Its effect is illustrated qualitatively by the floating needle previously mentioned.

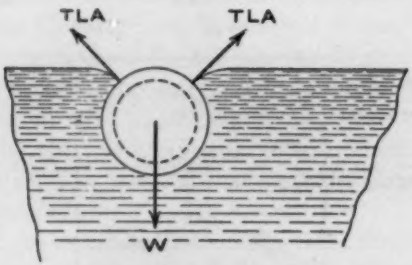
The law of least potential energy states that every physical system tends toward a condition in which the potential energy of the system is least. Familiar examples of the manifestations of this law are the tendency of water at the top of a hill to flow to the bottom and reduce its capacity to do work—in other words, reduce its potential energy; and the tendency of a stretched elastic or spring to decrease its own length—in other words, reduce its ability to do work or come to a condition of least potential energy.

Bearing these two conceptions in mind, it will be seen that the spreading of oil on the surface of the sulphide, thereby displacing water from that surface, is a manifestation of the prin-

ciple of least potential energy. Further, we may conclude that the energy of the oil-sulphide interface is less than that of the water-sulphide interface, since such a condition only would allow for the spreading of the oil. Similar reasoning leads us to the conclusion that the energy of the water-gangue contact is less than that of the oil-gangue contact.

If, now, we consider an oil-water boundary as the fixed part of a system composed of oil, water, sulphide and gangue (Fig. 8) and the sulphide and gangue particles the movable parts of the system, and if we consider the solid particles presented at this boundary, the sulphide will tend to pass into the oil, because such

FIG. 3.



Floating steel cylinder ("greased needle"). Tangent to liquid surface at gas-liquid-solid contact makes large angle with horizontal and cylinder floats.

a position will represent for it the position of least potential energy, while the gangue will tend to pass into the water for the same reason. If, then, we can form a system of oil, water, gangue, and sulphide in which all the sulphide and gangue particles are presented at the oil-water boundary for sorting, we shall have a means of selecting the gangue from the sulphide. And if, after such selection has taken place, the selecting surfaces with their selected sulphide can be separated from the body of the pulp containing the worthless gangue, we shall have completed a process of concentration. This is done by introducing into the sulphide-gangue-oil-water system a large number of air bubbles. Whenever one of these bubbles, in its movement through the pulp, comes into contact with an oil globule, the oil will spread over the air-liquid interface under the action of the law of least potential energy, for the reason that the energy of an oil-air interface is less than that of an air-water interface, and an oil-air contact

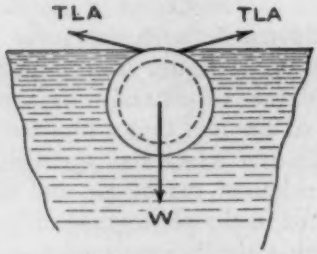
represents, therefore, a state of less potential energy than an air-water contact. At the surface of each such air bubble in the pulp there will be an oil-water interface for sorting sulphide from gangue (Fig. 7), and the sulphide will move into the oil away from the body of the pulp. As the bubble moves to the surface of the pulp through the influence of gravity the oil with its load of sulphide will move with it. At the surface the mass of sulphide-loaded bubbles will persist to form a froth.

FROTH FORMATION.

The mechanics of froth formation can best be explained by the following series of experiments. Persistent bubbles, hence a froth, cannot be formed in water alone. This is due to the fact that a pure-water film cannot, except by the merest accident, come to a state of equilibrium between the force seeking to distend the bubble and the surface tension. Neither can a froth be formed with pure oil. A mixture of oil and water can be made to froth slightly on account of the fact that a film forms at the interface between the oil and water which has a sufficiently high viscosity to overcome the tension of the oil-air and oil-water interfaces. This film is illustrated in the photograph, Fig. 5, the phenomena of which are diagrammatically represented in Fig. 6 on the same plate. The photograph represents a square glass cell, having at the bottom a layer of water colored with red ink, and above a layer of kerosene. The red ink is added in order to make the phenomena more easily visible. Air is introduced through a tube into the water layer, the bubbles rise to the interface between the water and oil, and here immediately the viscosity of the interfacial film is apparent in the way in which the film is drawn up by the air bubble, as illustrated at *H*, Fig. 6. Eventually the bubble breaks free and rises through the oil layer with a coating of colored water, as illustrated at *M*, Fig. 6. This bubble rises to the surface and assumes momentarily the shape shown at *C*, Fig. 6. Shortly this water sheath falls away and drops back through the water layer in a bowl-shaped mass, as illustrated at *P*, Fig. 6. At the same time there may be seen dispersed through the oil the tadpole-shaped water drops illustrated at *T*, Fig. 6. The water drops *P* and *T* are conclusive evidence of the high viscosity of the interfacial film between oil and water. It is apparent, of course, that, since the energy of the interface between the oil and

the water is a constant, the drop will tend to assume the condition of least potential energy by reducing its surface to the minimum, and, the sphere being the body of least surface for a given volume, the drop will tend to assume a spherical shape. But, since the drops do not assume the spherical shape under the influence of surface tension, it must be further apparent that their tendency to do so is opposed by some other force. This force is the viscosity of the interfacial film. Such a viscous film aids a bubble with an oil-water film to persist and is one of the causes of the temporary persistence exhibited by bubbles formed from a mixture of oil and water. The other cause of such persistence is the

FIG. 4.



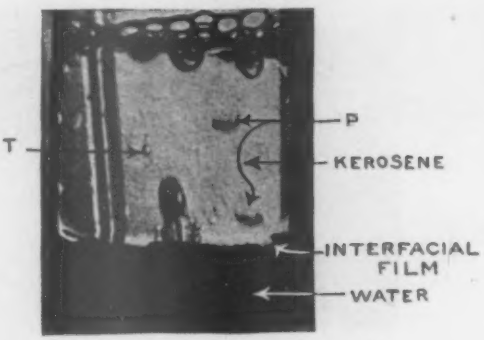
Sinking glass cylinder. Tangent to liquid surface at gas-liquid-solid contact makes small angle with horizontal and cylinder sinks.

variable surface tension of the oil-water film. Such a film, when subjected to a stress greater than its surface tension can resist, stretches, and in so doing increases its area. The concentration of the substance of lower surface tension (the oil) per unit of area now becomes less and the resultant tension of the film increases. If the increase is sufficient to balance the external stress, equilibrium is attained and the film persists.

In the flotation process this variability in surface tension is but a small factor in the stability of the film. The great factor is increase in viscosity, due, however, not so much to the viscous films at the oil-water interfaces as to the introduction into the bubble films of finely divided solid matter. The stabilizing effect of finely divided solid matter on liquid films is familiar to every one in the action of rain drops on a dusty road. Such drops will become coated with dust, and, if the surface of the road is hard and sloping, these dust-covered drops will roll for a considerable

distance along the surface, preserving their spherical shape. The phenomenon can be illustrated in the laboratory by floating a match on the surface of a beaker of water; placing a chip at the side of the beaker, then causing the match to revolve slowly, when it will be seen that the match can be turned around the vertical axis of the beaker without any corresponding motion of the chip. If, now, the surface of the beaker is dusted over with finely divided solid matter, a film forms, and when the match is again caused to rotate the film and the chip—in fact, the whole surface of the contents of the beaker—move with the match. This, of course, can be due only to the increase in viscosity of the surface film. The surface of an oil-coated air bubble in a

FIG. 5.



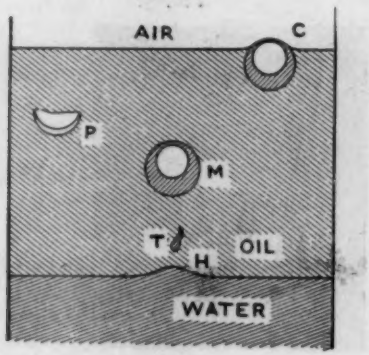
pulp, after it has picked up its load of solid, is similar to the water surface just described.

No physical principle other than the law of chance need be appealed to in order to explain the meeting of oil globules with air bubbles, or the meeting of sulphide particles with oiled bubbles. There are about three hundred million solid particles of the size that we are considering formed from every cubic inch of solid matter. In a flotation pulp (mixture of ore and water as sent to the machine) there are at least sixty million particles per cubic inch. The opalescence caused by agitating together the water and oil before addition of the ore will show that the oil is as thoroughly dispersed. Given, then, at least sixty million particles of solid and sixty million oil particles per cubic inch, and introduce air bubbles, in the same or greater number, and failure of the

air bubbles, oil globules, and sulphide particles to collide will take some phenomenal steering. It is obviously unnecessary to appeal to any mysterious forces to bring about a meeting.

To summarize, then: We bring to the machine a freely flowing mixture of ore and water, the pulp; we add oil; agitate to disperse the oil through the pulp; agitate further to introduce air in finely divided form, and agitate yet further to cause the air bubbles to come into contact with oil and sulphide particles. The oil spreads over the surface of the air bubbles because by so doing it lowers the potential energy of the oil-air-water system. A sulphide particle subsequently meeting the oiled air-bubble passes into the oil film because in this position it is in the state of

FIG. 6.



least potential energy, and the gangue particle, meeting the oiled air bubble, passes back again into the water because this position for it represents the state of least potential energy. The sulphide-coated, oiled air bubble rises through the pulp, due to its smaller specific weight, and upon reaching the surface of the pulp persists, on account of the high viscosity of the solid-loaded film surrounding it. The froth formed by the persistent bubbles is scraped off and a separation is thus made between the sulphide and the gangue originally present in the ore.

COMMERCIAL MACHINES.

Commercial froth flotation machines are of three types: (1) the so-called mechanical agitation machine, which depends solely upon mechanical agitation for the dispersion of the oil in the pulp

and the introduction of air; (2) the pneumatic froth machine, in which the air is introduced through a porous bottom, the only agitation to which the pulp is subjected being the gentle agitation due to the rising of the mass of air bubbles through the pulp; and (3) the so-called mechanical-air machine, which is a combination of the other two, using mechanical agitation for dispersion of the oil through the pulp and for the introduction of part of the air, and having also an arrangement for introducing air through a porous bottom under the mass of pulp which has been previously subjected to mechanical agitation.

The mechanical agitation machine consists, in the best form, of an agitating compartment above which is mounted a vertical

FIG. 7.

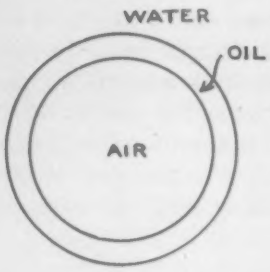
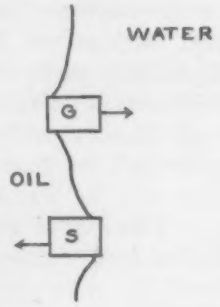


FIG. 8.



motor with an extension shaft reaching down into the box and bearing two cross-shaped beaters. Pulp is introduced into this box through a pipe near the bottom, is agitated by means of the beaters, and discharged over the top underneath a baffle, below the surface of the pulp in the two pointed boxes, or *spitzkasten,* placed one at either side. These *spitzkasten* afford a quiet place in which the pulp comes to rest allowing the bubbles with their load of sulphide to rise to the surface and collect as a froth. The froth is removed mechanically by means of scrapers. The material not in the froth settles to the bottom, part of it passes on into an adjoining *spitzkasten,* and part of it is sucked back through a pipe, into the beater box again. This cycle is repeated a sufficient number of times to insure the saving of a large part of the sulphide mineral. These machines are set up in batteries of from 6 or 7 to 16 or 17 in series.

The pneumatic froth machine is typified by the Callow cell. This consists of a box 18 inches to 2 feet wide, 6 feet to 10 feet long, with a sloping porous bottom ranging in depth from 8 or 10 inches at the head end to about 4 feet at the discharge end. Pulp is fed into the box at the shallow end, behind a baffle, flows out into the main box, and is there subjected to the action of a rising column of bubbles formed from air introduced through the porous bottom. The porous bottom is divided into compartments, each with a separate air supply, the purpose being to so regulate the air as to just overcome the hydrostatic pressure at each depth. The froth overflows at the sides of the box into launders and is carried away as concentrate, while the tailing is discharged through a valve at the lower end of the machine.

The best-known mechanical-air machine differs from the mechanical machine first described only in that the *spitzkasten* are fitted with porous bottoms through which air is introduced into the already partly aërated pulp discharged from the agitating compartments. This air lightens the froth materially, makes it much more tender, yet by greatly increasing the number of bubbles rising through the pulp lessens the number of sulphide particles which drop to the bottom of the *spitzkasten* and pass off into the tailing. The use of air also does away with the necessity for mechanical froth removers.

FLOW SHEETS.

The way in which mills using flotation are arranged depends upon the way in which the sulphide mineral occurs in the ore. There are perhaps three typical mill installations in which flotation is used. The first of these applies to an ore in which the sulphide mineral occurs in relatively coarse aggregates. Such an ore is treated by crushing to the point where a portion of the mineral is severed from the gangue, then commences a scheme of sizing and classification, the various coarser sizes being treated by water concentration to remove concentrate, making a middling product which is sent to regrinding machines. The finest product of the preliminary grinding and the products of the regrinding machines are combined and sent to the flotation plant. This is a typical mill scheme where flotation has been introduced as a slime-treatment accessory to older processes, and is the most economical scheme where the mineral is sufficiently coarse so that

a considerable portion of it can be removed with good recoveries by water concentration.

The second type of mill is that in which the sulphide mineral occurs disseminated as minute grains throughout the ore. In the treatment of such an ore it is necessary, in order to sever the sulphide grains from the gangue, to grind very fine in the first instance; in other words, to slime the whole pulp. When such a process is carried out the whole mill feed is sent to the flotation plant and little or no gravity concentration is attempted.

The third type of flow sheet applies to ores in which the sulphide mineral is not quite so finely disseminated as in the last instance, but where the amount of mineral coarsely disseminated is not large. In such a case it has been deemed economical to grind all the pulp down to such size that the flotation machines can move it without banking, and yet not to such size that all the sulphide mineral can be raised in the froth. The pulp thus ground is passed first to the flotation machines, which take out the fine sulphide particles. The tailing from these machines is then passed to gravity concentrating devices, where the coarser sulphide is taken out, and the reject from these machines is discharged from the mill as finished tailing.

The actual flotation plant is arranged according to two general schemes: (1) The so-called roughing-cleaning scheme, and (2) the so-called concentrate-middling scheme. In the first of these the concentrate from the first cells is taken off relatively dirty and sent to another set of machines called cleaners, which make a high-grade concentrate and discharge a relatively rich pulp. This latter constitutes a middling which is ordinarily joined with the froth from the later cells of the rougher machine and the whole sent back to the head of the rougher machine for retreatment. The pulp discharged from the rougher machine constitutes tailing. In the concentrate-middling scheme the first cells are run to give a clean concentrate. The later cells are run to take over dirty froth and insure the discharge of a clean, impoverished tailing. The dirty froth is returned as middling to the head of the machine.

Applicability.

Flotation can be applied to any ore in which the mineral containing the valuable metal has a metallic lustre and the gangue

has a vitreous or earthy lustre. If the gangue also has metallic lustre or two minerals, such as the sulphides of lead and zinc occur together, the problem of differential flotation arises. This problem cannot be said to be yet completely solved. When the valuable metal is combined with oxygen alone or with oxygen and carbon or silicon, giving oxides, carbonates, or silicates, the so-called oxidized ores, another unsolved problem arises, so far as flotation is concerned, although some successful experiments on such ores have been reported. We may expect to see both of these problems solved in the not-too-distant future.

Some Large-Scale Experiments Imitating the Craters of the Moon. HERBERT E. IVES. (*Astrophys. Jour.*, Nov., 1919.)—On the surface of the moon are features consisting of circular rings of the material of this body, elevated above its surface and surrounding level floors higher than the surrounding lunar surface. Small peaks often rise from these floors. Volcanic action and the impact of meteorites have both been invoked to explain the presence of these craters.

At Langley Field, Virginia, during the war, craters were made by the explosion of bombs dropped from airplanes. Photographs of these taken from airplanes very closely resemble photographs of the lunar craters. The central surrounding wall, the central peak and radiating streaks all are there. The similarity extends even to overlapping craters. Could explosions have caused the lunar craters? To the earth's atmosphere come meteors with velocities ranging from 16 to 64 kilometres per sec. These sometimes become incandescent and burst with loud reports. Owing to the protection afforded by the envelope of air they rarely pit the surface of the earth. The moon, however, has no atmosphere. A meteor, travelling with the lowest speed given above and with an assumed specific heat of .2, would be raised to a temperature of 15,000°C. upon colliding with the surface of the moon, even if nine-tenths of the heat developed were given up to the surroundings. This high temperature would turn any substance into a gas at once and would be the equivalent of an explosion. The crater is thus not the result of the direct impact of the meteor upon the lunar surface but of the consequent development of gas. The angle of incidence of the meteors is of small moment. Though they bombarded the moon from different directions the craters formed did not register those directions since they were thrown up by the outrush of gas.

G. F. S.

ON THE MODE OF FORMATION OF DUST FIGURES ON WALLS AND CEILINGS.*

BY

C. B. BAZZONI, A.M., Ph.D.

THE dust figures which occur on the walls and ceilings of rooms frequently outlining the laths and other underlying structures have been commented upon at different times in scientific periodicals.[1] The figures have been attributed by some to deposits of moisture, and by others to electrostatic or thermal effects.

These figures are of two types. Those of the first type are, in the opinion of the writer, to be referred to local temperature differences on the wall surfaces which cause corresponding irregularities in the moisture deposition from the currents of damp air flowing over them. Areas with a temperature below the dew-point of the vapor in the air become covered with a water film which takes up the dust particles from the air by ordinary adhesion. This dust deposit is possibly increased through deposition resulting from the checking in the velocity of the air current due to the greater surface friction over the wet areas. This simple theory suffices to explain all of the dust figures outlining underlying structures ordinarily observed.

The most common dust figure of this type is that showing up the laths and beams under the plaster. The black areas making up these figures are found to be between the laths. These figures are never marked, if at all present, in interior rooms or on the ceilings of lower story rooms where upper stories are heated. They occur fully developed on the ceilings of rooms covered by a cold attic and on the inner sides of exterior walls. The more rapid convection and radiation of heat from the areas not backed by lath or beam produce the necessary local temperature differences for the production of the irregular water films. A striking illustration of this theory is shown where beams contain tie-bolts or large lag screws the heads of which are covered by the plaster. The locations of these iron bolts are indicated in the dust figures

* Communicated by Dr. Joseph S. Hepburn.

[1] T. D. Cope: *Nature*, vol. xciv, p. 562, Jan. 21, 1915.

by intense black deposits of the size of the bolt head. The greater amount of the deposit is due to the more rapid conduction along the iron bar and the consequent lower temperature at the end. All observations, in short, indicate that for the production of well marked figures the outer side of the wall must be at a lower temperature than the inner and that the rate of heat loss must be greater from some portions of the area than from others.

Figures of the second type occur at the edges of mouldings, cornices or other obstructions which are so situated as to impede the flow of the ordinary ventilation air currents. They are also observed across the edges of cracks in the plastering. These dust figures form irregular streamers at the boundaries of the obstacles in the direction of the air currents. These are surface layers having no relation to the underlying structures of the wall. We may assume these deposits to be produced like the others by the adhesion of dust to moist areas, but the deposition of the moisture can no longer be generally ascribed to temperature differences on the surface. The slight increase in pressure around the obstacle due to the current flow seems the only possible cause of the assumed precipitation of moisture in these cases. On the other hand, the entire deposit may be explained as the effect of the decreased velocity and consequent decreased carrying capacity of the air stream in the immediate neighborhood of the obstacle —adhesion between the greasy dust and the wall taking place with no greater amount of water present than that usually found on the walls of heated apartments. No deposits of this type have been examined by the writer, the formation of which cannot be superficially explained on the basis of this simple hypothesis of deposition in areas of decreased velocity—adhesion following from the ordinary stickiness of the wall.

The explanations of the formation of dust figures given above have been subjected to simple experimental tests in this laboratory. An experimental chamber was constructed about 70 cm. by 30 cm. by 20 cm. in size. The roof was formed by a sheet of compo-board surfaced with Alabastine and resurfaced when necessary. At one end of the box was a glass window made to slide up and down so as to cover or uncover a row of ventilating ports. An iron pipe of 3 cm. bore and 60 cm. in length was brought through the floor at the other end of the box. This pipe had a perforated cork at the bottom through which air, chemically dried,

could be sent by means of a motor driven blower. The cork also supported an electric resistance heater wound on a porcelain pipe. Two glass tubes entered the iron pipe laterally. One of these, about half way up, was used to admit steam when desired —the other, three-quarters of the way up, to admit dust. The dust used was dried precipitated lampblack. This powder was contained in a glass receptacle and was blown into the tube axially by means of a second motor driven blower. With this arrangement a sustained current of warmed air could be circulated through the chamber, passing in its path along the ceiling. This air could be dry or moist as desired and could be supplied with any desired content of dust. It was found that where moist, dusty air was desired so as to get rapid and certain results the best effects were produced by inserting a bunsen burner burning with a smoky flame into the bottom end of the iron pipe after removing the cork and heater. It was also found that the heater could in all cases be substituted for by heating the tube on the outside with a bunsen or blowpipe flame.

The following experiments were performed:

(1) A cold spot was produced on the ceiling by placing on the top of the chamber, outside, a can containing running cold water. A hot spot was made beside the cold spot, but several centimeters distant from it, by placing a circular flat plate electrical heater on the outside of the box lid. With moist, smoky air driven by a smoky bunsen flame visible figures were produced on the ceiling in one minute or less. The cold spot was heavily blackened—the hot spot remained notably cleaner than the rest of the ceiling. The figures had sharp, clean edges.

(2) The box was dried overnight with a large vessel of calcium chloride. The hot and cold spots were produced as before. A current of warm dry air was run through the chamber for fifteen minutes without producing any effect on the clean ceiling surface. Next dust was introduced with the air and kept circulating heavily for fifteen minutes. Large quantities of dust settled in the box but no figures appeared on the ceiling. Next steam was introduced with the dust. A dark figure appeared within a few seconds on the cold spot. After fifteen minutes the ceiling was removed for closer examination. Definite sharp figures were found as in the preceding experiment—dark under the cold spot —white under the hot spot. After the dust had settled a fresh

ceiling was substituted and steam was introduced into the chamber with dust free air. After ten minutes the cold spot was clearly indicated by a moist darkening of the surface due to deposited water.

(3) The object of this experiment was to show that water actually deposited in detectable amount on the cold spot and evaporated from the hot spot. The ceiling was painted with blue litmus solution and then treated with HCl vapor to turn the litmus red. The Alabastine has a natural alkaline reaction so that wherever this prepared red surface was touched with water it turned blue. On the other hand, when the surface was thoroughly dried and the HCl driven off the pink color disappeared, leaving a greyish color like neutral litmus. After passing moist, dust free air through the chamber for ffiteen minutes the cold spot was found to be distinctly blue, the main ceiling surface red and the hot spot grey. The effects were sharply defined like the dust figures.

These experiments show that dust figures of the type studied are produced only in the presence of moisture, and that their configuration is the same as that of the moisture deposits formed by the natural condensation on cold areas and evaporation from hot areas. The formation of the figures is not dependent on the temperature differences excepting in so far as these temperature differences determine the moisture distribution on the surface.

Peculiar graduations in density are frequently observed in the figures on walls, apparently due to an irregular placing of the underlying structures bringing the conducting materials nearer the surface at some places than at others and thus producing a temperature variation on the surface. A fourth experiment was made to determine the effect of small differences of temperature on the densities of the figures.

(4) Four vessels were placed in a row crosswise on the lid of the experimental chamber: (*a*) A can with a flat bottom containing salt and ice—temperature 6°C.; (*b*) a glass beaker containing water—temperature 29°; (*c*) a beaker containing water—temperature 25°; (*d*) a can with a flat bottom cooled with running water —temperature 15°. The beakers had concave bottoms so that they touched only at the edges of their bottoms. After exposure to circulating moist, dusty air for fifteen minutes four definite dark figures were formed. Figure (*a*) was distinctly the most dense;

(*b*) could be seen only with difficulty; (*c*) was easily seen, but not dense; (*d*) was not so heavy as (*a*) but much heavier than (*c*). The deposits under the beakers were distinctly annular, being lighter in the centre. It is clear from this experiment that the density of the figure is a function of the temperature of the area and that the figure will exhibit quite accurately the temperature distribution over the area. The greater temperature difference produces the greater deposition because of the more moist condition of the colder area. It was found, however, that for brief and extreme tests a limit was reached when the temperature was sufficiently low and the moisture sufficiently abundant to form a continuous layer of water with drops. This layer naturally served to protect the surface from actual contact with the dust so that the figure became very light after drying in the open air. The temperature on the top surface of the lid during this experiment was 32°. Immediately below the ceiling, inside the box, the temperature was 42°.

(5) It is possible to imagine that some sort of thermal action may go on in the thoroughly dry apparatus which does not become evident because the dust cannot stick to the under surface of the ceiling but falls away and therefore does not produce any figures. To test this point the ceiling surface was turned upward and supported about three centimeters below the top of the box, the roof being a sheet of glass. The hot and cold spots were produced from underneath. It was found that, when the ceiling board had been very thoroughly dried by heat and dried air and no trace of moist air was present, the dust deposit formed was uniform and unfigured, but that in the presence of the slightest trace of moisture such, for example, as could be produced on the surface by blowing off an accumulation of dust with the breath, definite figures of the usual sort began to appear at once. With moist air or with air driven by a smoky bunsen flame, dense and sharp effects were produced in a very few minutes.

These experiments seem sufficiently conclusive as to the mode of formation of dust figures of the first class—those occurring on flat surfaces on which a temperature inequality exists. The figures produced around obstacles were next studied. Three obstacles were fastened in a row across a clean ceiling surface. The first obstacle was a wooden cylinder about three cm. in diameter and one cm. high. The second was a cube of one cm. edge

and the third was a body about four cm. long by eight mm. at its widest part of approved stream line form. Experiments were performed as follows:

(1*a*) It was first established that figures similar to those observed on ceilings could be formed under the conditions of the experiments. Smoky, moist air driven by a smoky bunsen burner was passed through the chamber. Figures of the characteristic forms began to appear around the obstacles within one minute and were well marked after five minutes.

(2*a*) It was next shown that the figures do not form around dry obstacles on a horizontal ceiling in a current of dry, dusty air. Dry dust filled air was passed over a clean ceiling with obstacles for fifteen minutes. At the end of this time there was absolutely no effect visible in the way of figures.

Figures produced by the methods of (1*a*) seemed, on examination, to suggest strongly that the dust was deposited in areas of positive pressure and cleared away from areas of negative pressure. This was particularly the case around the stream line obstacle. The pressure changes to be expected around cylindrical and stream line obstacles in an air current of the velocity here used were calculated and were found to correspond in power to precipitate moisture to temperature changes not exceeding ½° C. These pressures seemed entirely inadequate to produce effects of the intensity actually obtained. Furthermore, the excess moisture deposition due to positive pressures around the cylinder should lie within a cone opening toward the air current of 70° apex angle while the dust deposition seemed uniform over 180° in the observed figures.

(3*a*) An attempt was next made to find out whether or not any moisture was deposited around the obstacles. A clean ceiling with obstacles was put in place and dust free air containing an excess of steam was passed over it for fifteen minutes. No moist areas appeared. Any considerable amount of moisture would have turned the Alabastine dark. The ceiling was then painted with blue litmus and the blue turned red with HCl vapor as in the first series of experiments. Continued exposure of this surface to currents of moist air failed to produce any figures around the obstacles. On increasing the steam content of the air the entire surface turned blue uniformly with no evidence of extra moisture near the obstacles. These tests served to prove what the calcula-

tions indicated—that no quantity of moisture detectable by the means employed was thrown down around the obstacles.

These results suggested that the figures obtained in (1*a*) were merely shadow effects due to the interference of the obstacles with the air flow velocity. The carrying capacity of a stream is usually assumed to vary with the cube or some higher power of the velocity whence any slight checking of an air stream will deposit dust from it although the associated pressure change may not be great enough to deposit any moisture. If this is the case the figures will form in dry air as well as in moist. Under the conditions of (2*a*) the dust deposited could not be observed, since it settled downward, neither the ceiling nor the dust being sticky.

(4*a*) To test this last assumption, the obstacles were set on the upper surface of a whitened compo-board supported three centimeters below the top of the box, inside, in such a way as to leave openings communicating downwards at either end. The lid of the box was a sheet of glass. Dry, dusty air was passed over the surface bearing the obstacles. Distinct figures of the usual form showed after a few seconds and could be made of any desired intensity by prolonging the flow. These were obviously deposition figures of dry dust due to checking the air current. They were nonadherent and could be blown completely away with a single breath. This experiment showed that the deposits formed, as was anticipated, in the absence of moisture, and explained why no deposit was observed in (2*a*). To get an obstacle figure on a ceiling from dusty air it is necessary to render the ceiling sticky. Water vapor will produce the necessary stickiness.

(5*a*) The internal plate was removed and the obstacles placed on the lower surface of the ceiling as before. Dry, dusty air was admitted with steam. After fifteen minutes the ceiling was found to be covered with a generally distributed adherent deposit with weak though definite figures around the obstacles—dark in front and light behind. These figures were clearly present, were of the same kind as those that occur on ordinary ceilings and were permanent in that they could not be blown off. More marked figures can be produced in the same length of time with a smoky bunsen flame as in (1*a*) apparently because the bunsen smoke is itself more sticky and finely divided than the dried lamp black introduced by the methods here used.

These ten experiments seem to show definitely how and why wall figures of the two types treated are produced. The facts proved are in accordance with what one would expect on the basis of ordinary physical common sense. On account, however, of the methods used in this work it is not claimed that other factors than those affecting the distribution of moisture films as influenced by temperature may not contribute in a minor way to the formation of figures of the first kind. It is merely contended that under all ordinary conditions the temperature-moisture distribution is the factor of predominating importance being necessary and sufficient to produce all of the observed effects.

SUMMARY.

The dust figures commonly observed on walls and ceilings are grouped into two classes. Certain experiments are described showing that those of the first class are due to irregular moisture deposition on the surface caused by a corresponding irregular temperature distribution, and that those of the second class are due to deposition around obstacles caused by decreased carrying capacity of the air stream with decreased velocity.

RANDAL MORGAN LABORATORY,
UNIVERSITY OF PENNSYLVANIA,
November, 1918.

Bacteriology in Food Control.—EDWIN O. JORDAN, of the University of Chicago, concludes a paper on the "Uses, Possibilities and Limitations of Bacteriology in Food Control" (*American Journal of Public Health*, 1920, X, 142–144), with a statement of the future outlook for the application of bacteriology in food control. "Increasing emphasis will be laid on bacterial methods as an aid to the interpretation of the sanitary inspection of foodstuffs and as a guide to satisfactory sanitary procedure. Continued laboratory investigation of the two best-known instances of so-called 'food poisoning' traceable to primary bacterial food contamination, botulism and paratyphoid meat poisoning, seems urgently called for since both are intimately connected with the vital problems of food conservation. Finally the nature and sanitary significance of the products generated by bacteria, particularly the so-called saphrophytic bacteria, in foodstuffs affords a practically untouched field for investigation."

J. S. H.

NOTES FROM THE U. S. BUREAU OF STANDARDS.*

A NEW FORM OF VIBRATION GALVANOMETER.[1]

By P. G. Agnew.

[ABSTRACT.]

VIBRATION galvanometers are very useful in a. c. null measurements, but have not been much used in industrial laboratories on account of their being sensitive to external vibrations and requiring delicate adjustments. The present instrument, which has a sensitivity higher than other forms of the moving-iron type, but less than that of the most sensitive forms of the moving-coil type, has the advantages of sturdiness, quick responsiveness and freedom from the effects of external vibration. It consists essentially of a fine steel wire mounted on one pole of a permanent magnet and so arranged that the free end of the wire may vibrate between the poles of an electromagnet through which flows the current to be detected. The motion of the wire is observed with a microscope.

The "resonance range" is about one per cent.; that is, if the frequency of the current is 1 per cent. above or below the frequency of resonance, the amplitude of vibration will be half as great as at resonance. The sensitivity is such that with a 1-ohm winding an e.m.f. of 3 microvolts may be detected, and with a 270-ohm winding a current of 0.05 microampere can readily be detected.

VAPOR PRESSURE OF AMMONIA.[2]

By C. S. Cragoe, C. H. Meyers, and C. S. Taylor.

[ABSTRACT.]

THE previous measurements of the vapor pressure of ammonia are briefly reviewed and tabulated. A detailed description is given of the apparatus and method employed in the present measurements throughout the temperature interval −78° to +70° C. Seven samples of thoroughly purified ammonia were used. Special tests showed less than 1 part in 100,000 by volume of

* Communicated by the Director.

[1] Technologic Paper No. 370.

[2] Scientific Paper No. 369.

non-condensing gases and less than 0.01 per cent. by weight of other impurities. The methods of purification and filling manometers are briefly described. The phenomenon of hysteresis was observed near the normal boiling point of ammonia with a commercial sample containing a small amount of air, which indicated the necessity of very complete removal of dissolved gases for any accurate measurements of vapor pressure by the static method. Lags in coming to equilibrium were encountered and studied in order to determine the most advantageous procedure in establishing equilibrium. The normal boiling point of ammonia was determined by the static and also the dynamic method, the mean of the results by the two methods being −33.35° C. Two empirical equations were found to represent closely the results in the temperature range covered experimentally and also the latest determination of the critical data for ammonia. The results of 122 measurements in the interval −78° to +25° C. made with direct observations of mercury columns agree with the empirical equations within 1 mm. of mercury. The results of 28 measurements in the interval +15° to +70° C. made with an accurately calibrated piston gauge agree with the empirical equations within about 3 mm. of mercury. As a final result the vapor pressure of ammonia is expressed in the range −80° to +70° C. by either of the following equations:

$$\log p = 30.256818 - \frac{1914.9569}{\theta} - 8.4598324 \log \theta + 2.39309 \times 10^{-3}\theta + 2.955214 \times 10^{-6}\theta^2$$

$$\log p = 12.465400 - \frac{1648.6068}{\theta} - 0.01638646\,\theta + 2.403267 \times 10^{-5}\theta^2 - 1.168708 \times 10^{-8}\theta^3$$

where p is expressed in mm. of mercury and θ in degrees absolute ($°abs = °C + 273.1$).

IONIZATION AND RESONANCE POTENTIAL FOR ELECTRONS IN VAPORS OF LEAD AND CALCIUM.[3]

By F. L. Mohler, Paul D. Foote, and H. M. Stinson.

[ABSTRACT.]

MEASUREMENTS of electron currents in three electrode vacuum tubes of the type previously described have been made in vapors of lead and calcium.

[3] Scientific Paper No. 368.

The lead and calcium were boiled in porcelain tubes at temperatures of about 1000° and 900°, respectively. Current voltage curves in lead showed a resonance potential of 1.26 volts and an ionization potential of 7.93 volts. Applying the quantum relation $Ve = h\nu$ we find that 1.26 volts corresponds within experimental error to the frequency of a strong infra-red spectrum line at $\lambda = 10{,}291$ Å giving a theoretical value of the resonance potential 1.198 volts.

In calcium two resonance potentials were found at 1.90 volts and at 2.85 volts of which the first is the most prominent. Ionization occurred at 6.01 volts. The ionization potential corresponds to the limit of the principal series $1.5\ S$, $\lambda = 2027$ Å giving as the theoretical value $V = 6.081$ volts. The first resonance is determined by the line $1.5\ S - 2p_2$ $= 6572.78$ Å, $V = 1.877$ volts. The second resonance corresponds to the line $1.5\ S - 2\ P$, $\lambda = 4228.73$ Å, $V = 2918$ volts.

The spectral relations of the first resonance potential and ionization potential are analogous to the relation found with other metals in this group. Work of other observers shows that both the lines $1.5\ S - 2\ P$ and $1.5\ S - 2\ p_2$ appear below the ionization potential in most metals of this group.

RECOMMENDED SPECIFICATIONS FOR ZINC OXIDE, DRY AND PASTE.[4]

[ABSTRACT.]

PREPARED and recommended by the U. S. Interdepartmental Committee on Paint Specification Standardization, January 12, 1920. This committee was appointed at the suggestion of the Secretary of Commerce, and consisted of representatives of the War, Navy, Agricultural, Interior, Post Office, Treasury, and Commerce Departments, the Railroad Administration, the Panama Canal, and the Educational Bureau of the Paint Manufacturers' Association of the United States. The committee submitted a preliminary draft of the specification to a large number of representatives of the paint and varnish industries, including the manufacturers of zinc oxide, and gave careful consideration to the replies received in time.

[4] Circular No. 87.

CONTRAST SENSIBILITY OF THE EYE.[5]

By Enoch Karrer and E. P. T. Tyndall.

[ABSTRACT.]

A KNOWLEDGE of the contrast sensibility of the eye is very essential to the proper understanding of the theory and use of Searchlamps and Searchlight Illumination.

The searchlamp is used at night when the eye is generally adapted to low levels of illumination. If the observer is far removed from the searchlamp the illumination may be simply that from the moon and sky. If he is near the lamp, however, he must look through the diffused light along the beam.

In order to be visible, the target must be illuminated to a degree that will make sufficient contrast in brightness or color between it and this surrounding field. Data are given showing the relationship that exists between the brightness and the size of the target and the brightness of the surrounding field.

In these experiments a large surface painted white was illuminated with an incandescent lamp. The target consisted of a rectangular spot of this surface more brightly illuminated by means of a projection lantern, equipped with a simple bilateral slit. The image of the slit determined the boundaries of the test spot or "target," the length of which could be varied by varying the slit width. Precautions were taken to have the brightness across the image of the slit uniform. The brightness of either the test spot or field could be varied by means of sectored discs, so that any desired contrast between them could be obtained for any given brightness of field.

Curves are given showing relation between length of test spot and the brightness of the field for various contrasts, and also curves showing relationship between the length of test spot and contrast between field and spot for various values of the field brightness.

TURBIDITY STANDARD OF WATER ANALYSIS.[6]

By P. V. Wells.

[ABSTRACT.]

THE amount of suspended matter in water is estimated by its turbidity, hence, a reliable standard of turbidity is necessary.

[5] Scientific Paper No. 366.
[6] Scientific Paper No. 367.

To develop such a standard was the object in view when this investigation was undertaken.

The optical principles of turbidity and the results obtained by classic theories on the subject are summarized. Various methods in vogue for measuring turbidity have been repeated with the purpose of determining their comparative reliability. Turbidity standards from a number of water laboratories were obtained and compared. Tentative suggestions are given for avoiding the large variation between standards which was found.

RECOMMENDED SPECIFICATIONS FOR LEADED ZINC OXIDE, DRY AND PASTE.[7]

[ABSTRACT.]

PREPARED and recommended by the U. S. Interdepartmental Committee on Paint Specification Standardization, January 12, 1920. This committee was appointed at the suggestion of the Secretary of Commerce, and consisted of representatives of the War, Navy, Agricultural, Interior, Post Office, Treasury, and Commerce Departments, the Railroad Administration, the Panama Canal, and the Educational Bureau of the Paint Manufacturers' Association of the United States. The committee submitted a preliminary draft of the specification to a large number of representatives of the paint and varnish industries, including the manufacturers of leaded zinc oxide, and gave careful consideration to the replies received in time.

RECOMMENDED SPECIFICATIONS FOR TURPENTINE (GUM SPIRITS AND WOOD TURPENTINE).[8]

[ABSTRACT.]

PREPARED and recommended by the U. S. Interdepartmental Committee on Paint Specification Standardization, October 27, 1919. This committee was appointed at the suggestion of the Secretary of Commerce, and consisted of representatives of the War, Navy, Agricultural, Interior, Post Office, Treasury, and Commerce Departments, the Railroad Administration, the Pan-

[7] Circular No. 88.
[8] Circular No. 86.

ama Canal, and the Educational Bureau of the Paint Manufacturers' Association of the United States. The Committee submitted a preliminary draft of the specification to a large number of representatives of the naval stores industries and the paint and varnish industries, and gave careful consideration to the replies received in time.

Tests of Dopes and Fabrics. (*Aircraft Technical Note, Bureau of Construction and Repair, Navy Department.*)—Dopes made from cellulose acetate have for some time been given preference in aircraft work, though more expensive than those made from the cellulose nitrate. The former product requires the use of acetic acid and acetic anhydride in its manufacture, which chemicals are costly and needed for other important industries. It has been found that the admixture of from 5 to 8 per cent. of ammonium phosphate or ammonium magnesium phosphate to the nitrate adds material fire-resistance properties. The subject of non-inflammable fabrics has also been studied, samples having been submitted for the purpose. It was found that these had been prepared by impregnation with ammonium phosphate. These fabrics are measurably fire-resisting, since when ignited a notable amount of ammonia is evolved, which quenches the flame.

H. L.

Waterproof Finishes. (*Aircraft Technical Note, Bureau of Construction and Repair, Navy Department.*)—The Forest Service has recently been experimenting with the waterproofing properties of wood-finishing preparations. Among other articles, a phenol condensation resin was tried, which was very efficient, but difficult to apply, as the wood must be well dried. Paraffin and beeswax, followed by varnishing, did not afford protection, and coating with metals by the spraying methods was also unsatisfactory, especially as it is likely that the coating will be torn by the centrifugal force developed in the rotation of the propeller. Good results, however, were obtained by filling the wood, varnishing, coating with the liquid used for making gold size, and then applying aluminum leaf. After drying, the surface is varnished with a highly waterproof varnish. Aluminum leaf is preferred on account of toughness. Experiments were made by coating electrolytically with copper. This makes a good resistance, but the metal does not adhere well. Good results were obtained with hard rubber (about 3 mm. thick). Good spar varnish, especially when four coats are used, gives excellent results, which are markedly improved by adding enamel, which indicates the advisability of using such enamel paints instead of plain varnish in all constructions exposed much to moisture.

H. L.

NOTES FROM THE RESEARCH LABORATORY EASTMAN KODAK COMPANY.*

NEW TURBIDIMETER FOR SOLUTIONS OF GELATINE, CELLULOSE, VARNISHES, ETC.[1]

By S. E. Sheppard.

A TURBIDIMETER for definite thickness of fluid is described. It is based on the continuously variable visibility of a standard object, consisting of two crossed gratings which can be rotated in opposite directions about a common axis. It is shown that for the practical limits of working if A_{max} be the angle for the visibility limit for any standard medium, *e.g.*, distilled water, lacquer solvent, etc., and if A be the angle for the same thickness of turbid solution, then putting A_{max}, $/A = 100/C$, the percentage clarity C, is obtained, $= 100\ A/A_{max}$.

The advantages of using per cent. clarity figures, instead of arbitrary turbidity figures, are emphasized, and the technic for use of very viscous solution with volatile solvents discussed.

CHEMICAL INDUCTION IN PHOTOGRAPHIC DEVELOPMENT. I. INDUCTION AND THE WATKINS' FACTOR.[2]

By S. E. Sheppard and G. Meyer.

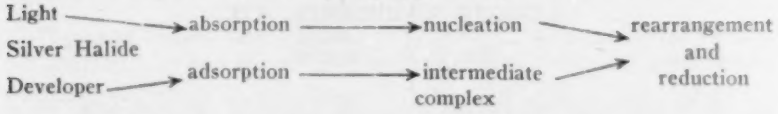
THE Lainer effect, which consists in the acceleration of development by dilute solutions of soluble iodides has been investigated quantitatively and found to affect chiefly organic developers of low reduction-potential, such as hydroquinone. Such developers, having a low Watkins factor, show a marked induction period; it is now shown that this is reduced by soluble iodide, the principal action of which is to increase the Watkins factor. The action is discussed in connection with the mechanism of development. Evidence is brought forward against Lüppo-Cramer's theory of "nucleus activation," and in support of the view that

* Communicated by the Director.

[1] Communication No. 81 from the Research Laboratory of the Eastman Kodak Company, published in *J. Ind. Eng. Chem.*, 1920, p. 167.

[2] Communication No. 84, published in *Phot. J.*, 1920, p. 12.

the action depends upon increased adsorption of the developing agent. The bearing of this view, including the possibility of a solid complex formation between developer and silver halide on the mechanism of development is discussed, the modification consisting in regarding the photo-chemical action of light and development as a process of coupling typified by:



In addition there is a fogging action of dilute iodide solutions, on silver bromide emulsions, which is ascribed to nucleus infection of the grain.

Technical Applications of Ethyl Chloride are described by ALBERT HENNING in *Journal of the Society of Chemical Industry, Transactions,* 1920, xxxix, 1–8. Commercial ethyl chloride has a high state of purity, it is not poisonous, and is not more inflammable than methylated spirit or benzine. High pressure apparatus is not required in its use, since its gauge pressure is only 12 pounds per square inch at a temperature of 30° C. Ethyl chloride is used as an ethylating agent in the manufacture of dyestuffs and pharmaceutical products, as a solvent, as a refrigerant, and as an anæsthetic, either local or general. On the basis of its ethyl content, ethyl chloride is the cheapest ethylating agent; when used for such a purpose in an autoclave, the stuffing-box of the latter should be provided with asbestos packing impregnated with glycerin. Ethyl chloride is a good solvent for fats, oils, and simple organic compounds, and may be used for their extraction. Organic compounds which contain several hydroxyl groups are dissolved to but a slight extent, if at all. A solid is obtained in crystalline form from its solution by cooling that solution; if the solvent be ethyl chloride, the crystals may be obtained by evaporation of the solvent under reduced pressure, for the temperature of the solution then falls to −15° or −20° C. Ethyl chloride is the best refrigerant for household machines, since it may be used at a low pressure, not exceeding 15 pounds per square inch. It is also used for this purpose in large machines on both land and ships. In chemical manufacture, when refrigeration is required, ethyl chloride may be used as the refrigerant, since it may be circulated directly through the apparatus; and circulation of cooled brine is entirely eliminated. When a spray of ethyl chloride is directed on a small object, the temperature of the latter may be reduced as low as −30° C.

J. S. H.

NOTES FROM THE LABORATORY, GENERAL ELECTRIC COMPANY.*

THEORY OF UNIMOLECULAR REACTION VELOCITIES.

By Saul Dushman.

FOR some time Dr. Langmuir and the writer have been working over the material for a paper on the velocity of chemical reactions. In the course of the discussion of this subject, more especially in the consideration of the radiation theory recently suggested by W. C. McC. Lewis, it occurred to the writer that in the case of unimolecular gas reactions, *e.g.*, the dissociation, $H_2 \rightarrow 2H$, a formula could be deduced for calculating the rate of reaction, which is much simpler than the purely empirical relation proposed by Lewis.

Assuming that the rate of dissociation of a gas A_2, at any instant, is porportional to the concentration of the gas in the undissociated (or molecular) state, we can express this assumption by means of the relation,

$$\frac{-dn}{dt}2 = k_2 n_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

n_2 = number of undissociated molecules per unit volume.
k_2 = reaction-velocity constant at the given temperature.

Since this relation means that the *fraction* of A_2 converted into the atomic state during any interval of time is independent of the concentration, it must therefore follow, as pointed out by Perrin, that the rate of dissociation is not dependent upon the frequency of collision between molecules of A_2. In other words, the value of k_2 in the above equation must be dependent only upon the *temperature* and the *internal structure* of the molecule.

The dimension of k_2 is t^{-1}, and does not involve either mass or volume. Furthermore, from the fact that the rate of dissociation cannot be infinitely great, it is evident that only a certain fraction of the molecules must be capable of dissociating at any instant, that is, are in the "active state." Since k_2 increases with the temperature, we can assume that the value of this fraction

* Communicated by the Director.

also increases (at the same rate as k_2) with the temperature. Following the considerations developed by Marcelin, Rice and Lewis. we can express the value of this fraction, α, at any temperature, T, by means of the reaction

$$\alpha = e^{-Q/RT}$$

where Q = heat of dissociation per mol A_2, and e and R have their usual signification.

Thus k_2 contains both α and a number which has the dimensions t^{-1}. Now, let us assume firstly that we can write $Q = Nh\nu$ (Haber, Lewis, etc.), where $N = 6.062 \times 10^{23}$ (the number of molecules per mol), h is Planck's constant, and ν is some vibration-frequency. Since $R/N = k = 1.372 \times 110^{-16}$ ergs/deg., we thus obtain the relation,

$$\alpha = E^{-h\nu/kt}$$

Since ν has the dimensions t^{-1}, we shall now make a second assumption that the value of the disssociated constant k_2 is given by the relation

$$k_2 = \nu e^{-h\nu/kT} \quad \ldots\ldots\ldots\ldots \quad (2)$$

$$\frac{Q}{Nh} e^{-\frac{Q}{RT}} \quad \ldots\ldots\ldots\ldots \quad (3)$$

In other words, the rate at which the molecules A_2 dissociate depends *only upon the heat of dissociation and the temperature.* The exact significance of this equation will be discussed more fully in the paper to be published shortly by Dr. Langmuir and the writer. That it has some kind of universal significance follows from Dr. Langmuir's observation that equation (3) is also applicable to the phenomena of evaporation and electron emission. Evidently it adds more mystery to the significance of the quantum constant h. Such discussion must, however, be postponed for the more comprehensive paper on this subject.

So far as the writer is aware, the only unimolecular reaction whose velocity constant has been measured directly is the dissociation of PH_3, for which, according to Trantz (*Z. S. f. anorg. Chem.* 106, 95, 1919), the value of k_2 at $T = 495$, is 10.2×10^{-3}, while Q has a value between 70,000 and 80,000 calories. By means of equation (3) and using the above value of k_2, we obtain the result $Q = 72{,}800$. The agreement is thus very satisfactory in this case.

The validity of equation (3) may, however, be checked indirectly from determinations of the equilibrium constants and consideration based on the kinetic theory of gases, as follows:

Let n_1 denote the number of atoms per unit volume at any instant. Then the rate of combination is given by the number of collisions. If it is assumed, as seems reasonable, that every collision between atoms results in the formation of a molecule, we derive the equation

$$\frac{dn_2}{dt} \sigma^2 n_1^2 G \sqrt{\frac{4}{3}\pi} \quad \ldots\ldots\ldots\ldots \quad (4)$$

where

σ = molecular (or atomic) diameter.

G = root mean square velocity of atoms

$$= \sqrt{\frac{3RT}{M}}$$

M = Atomic weight.

Hence,

$$\frac{dn_2}{dt} = \sigma^2 n_1^2 \sqrt{\frac{4\pi RT}{M}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4a)$$

If c_1 and c_2 denote concentration in mols per cm^3 of the dissociation products and undissociated substances, respectively, we have the ordinary relations,

$$\frac{-dc_2}{dt} = k_2 c_2$$

$$\frac{dc_2}{dt} = k_1 c_1^2$$

Since $c_2 = n_2/N$, and $c_1 = n_1/N$, *it* follows that the equilibrium constant,

$$K = \frac{c_1^2}{c_2} = \frac{k_2}{k_1} = \frac{Qe^{-Q/RT}}{N^2 h \sigma^2 \sqrt{\frac{4\pi RT}{M}}} \quad \ldots\ldots\ldots \quad (5)$$

In the case of H_2 and I_2, the equilibrium constants for the dissociation into atoms are known with a fair degree of accuracy. Data are also available for Br_2 and Cl_2, the last mentioned being very inaccurate. The following table gives the values of Q calculated by means of equation (5) from the observed values of K at different temperatures for each gas. The last column gives

the most reliable values of Q as derived from the temperature-coefficients of the equilibrium constant K. It is evident that the agreement is very satisfactory.

Gas	$10^8 \times \sigma$	T	Q calc.	Q obs.
H_2	2.0	2000	89,600	87,000
I_2	4.52	1073	36,300	36,000
Br_2	3.74	1000	46,600	46,160
Cl_2	3.30	1940	86,900	(86,000)

The Thermal Conductivity of Solid Insulators. W. M. THORNTON. (*Phil. Mag.*, December, 1919.)—An inspection of the measured values of the heat conductivity of insulators leads him to conclude that this quantity is equal numerically to the product of the coefficient of elasticity concerned in the propagation of sound by the density of the substance. He tabulates the three quantities: (*a*) heat conductivity; (*b*) product of coefficient of elasticity by density, and (*c*) square of the product of velocity of sound by density (this should equal the second of the three quantities by the known relation—velocity of sound equals the square root of elasticity divided by density) for quartz, various kinds of glass, graphite, marble, mahogany, deal, ice, paraffin wax. The agreement is striking. For India rubber and for cork, however, the rule breaks down. The author draws the conclusion: "The chief practical qualification of a material as a heat insulator is that it should be light and inelastic."

G. F. S.

Preparation of Arsenic Trichloride from White Arsenic and Phosgene.—L. H. MILLIGAN, W. A. BAUDE, and H. G. BOYD (*Journal of Industrial and Engineering Chemistry*, 1920, xii, 221–223) of the Edgewood Arsenal have prepared arsenic trichloride on both a laboratory and a commercial scale by the reaction between arsenious oxide (white arsenic) and carbonyl chloride (phosgene) in the presence of carbon as a catalyst. The carbonyl chloride, which is a gas, may be used as such or mixed with air; it is passed over a mixture of white arsenic and carbon which is heated to a temperature above 175° C., usually 200° to 260° C. The arsenious chloride, which is formed, is recovered from the resulting gases by passing them through a condenser. The yield is almost quantitative. Carbon dioxide is the other product of the reaction. It is suggested that this reaction of phosgene may possibly be used for the preparation of other inorganic chlorides.

J. S. H.

NOTES FROM THE U. S. BUREAU OF CHEMISTRY.*

THE HEPTOSES FROM GULOSE AND SOME OF THEIR DERIVATIVES.[1]

By F. B. LaForge.

[ABSTRACT.]

THE two epimeric guloheptonic acids were obtained by the cyanhydrin synthesis from pure gulose, and separated by converting them into their barium salts. The barium salt of the alpha acid, being crystalline and difficultly soluble in water, was easily purified. From the barium salt, the free acid was prepared as an uncrystallizable syrup. The phenylhydrazid was prepared and found to melt at .191°. It showed $(\alpha)_D^{20} = -15.4$. The syrupy acid, when reduced in the usual manner with sodium amalgam, yielded crystalline alpha guloheptose of the following properties: M. P. 185°–187°, uncorr. $(\alpha)_D^{22} = -65.65$. It was much less soluble in water than most sugars.

Upon further reduction of the sugar, alpha guloheptitol was obtained (M. P. 138°–141°). It showed a slight dextro rotation in borax solution.

This compound is identical with beta guloheptitol obtained by Pierce (*J. Biol. Chem.*, **23**:327).

The compounds of the beta series were prepared from beta guloheptonic acid, which remained as the barium salt in solution after the crystallization of the alpha compound.

The free acid which still contained some of the alpha derivative was reduced with amalgam and freed from sodium salts by means of alcohol. The resulting mixture of beta guloheptose, together with some of the alpha sugar and some of the unreduced acid, was mixed with glacial acetic acid in which the alpha compound is almost insoluble. By this means a syrup containing almost no alpha sugar was obtained. Upon reduction of the resulting mixture with amalgam it was possible to prepare a syrup which yielded the benzal derivative of beta guloheptitol. From the

* Communicated by the Chief of the Bureau.

[1] Published in *J. Biol. Chem.* **41**, 251, 1920.

purified benzal derivative the beta heptitol was obtained by hydrolysis. This compound melted at 128°–129° uncorr., and showed an optical activity too small to be measured.

THE ARSENATES OF CALCIUM: I. EQUILIBRIUM IN THE SYSTEM ARSENIC PENTOXIDE, CALCIUM OXIDE, WATER AT 35° (ACID SECTION).[1]

By C. M. Smith.

[ABSTRACT.]

CALCIUM arsenate has recently become important as an agricultural spray material, particularly in connection with the fight to control the boll weevil in the southern cotton fields.

Owing to the harmful action of so-called "soluble arsenic" on plant tissues, it is necessary to know in detail the action of water on any arsenical spray material. In this case a general study of the system As_2O_5, CaO, H_2O at 35° was attempted. The present paper covers only the range in which the solutions are acid to phenolphthalein.

Numerous empirical mixtures of the three components were made. After agitation for a suitable period, these were filtered, and both filtrates and wet residues analyzed. Graphical analysis then led to a knowledge of the composition of the solid phases. Finally the results were interpreted in terms of the phase rule criteria.

Three compounds have been found to exist in the region investigated. Dicalcium arsenate monohydrate, $CaHAsO_4.H_2O$, which occurs in nature as the mineral Haidingerite, exists in contact with solutions which vary almost linearly from 0.10 per cent. CaO, 0.20 per cent. As_2O_5 to 6.8 per cent. CaO, 27.5 per cent. As_2O_5. The latter is the invariant point at which the second solid phase, monocalcium arsenate $CaH_4(AsO_4)_2$, appears. This monocalcium arsenate is stable in contact with solutions which vary approximately linearly from the above-mentioned invariant point to another invariant point at 0.11 per cent. CaO, 72 per cent. As_2O_5. Here the third solid phase, $3As_2O_5.5H_2O$, makes its appearance. The arsenic in solution at the second invariant point agrees quite well with the solubility of the hydrate $3As_2O_5.5H_2O$ as determined by other investigators (Menzie and Potter).

[1] Published in *J. Am. Chem. Soc.*, **42**, 259, 1920.

A graph given in the JOURNAL article shows the various relationships mentioned here, and permits of the prediction of the behavior of any empirical mixture of As_2O_5, CaO and H_2O within the region investigated.

ALKALI FUSIONS: I. THE FUSION OF SODIUM p-CYMENE SULFONATE WITH SODIUM HYDROXIDE FOR THE PRODUCTION OF CARVACROL.[3]

By H. D. Gibbs and Max Phillips.

[ABSTRACT.]

AN apparatus which is particularly well adapted to the study of alkali fusions has been devised in the Bureau of Chemistry. It consists of a bath of melted tin-lead alloy, properly insulated and heated by means of gas. The temperature of the bath can be maintained very nearly constant. The mixture to be fused is placed in six fusion tubes, made of heavy steel and provided with screw caps and copper gaskets, which can be screwed down until they are gas-tight. A system of racks and gears makes it possible to lower the tubes, which are firmly held on a carrier, into the bath. These tubes are revolved by means of an electric motor through a proper mechanical device, the tumbling motion thus imparted mixing the molten contents thoroughly. With this apparatus six points on a curve may be obtained in one run.

Using this apparatus, a study was made of the yield of carvacrol obtained when sodium cymene sulfonate is fused with sodium hydroxide. In order to determine the optimum conditions for obtaining the highest yield of carvacrol, it was necessary to study the following factors which influence the yield: (1) Proper fusion temperature; (2) proper fusion period; (3) ratio of sodium hydroxide to the sodium cymene sulfonate; (4) relation between the carvacrol yield and the percentage of water in the charge.

The results obtained show that the best yield (75 per cent.) of carvacrol was obtained when the fusion was conducted at 350° C. When fused at this temperature, six hours seemed to be the optimum fusion period. So far as the sodium hydroxide is concerned, a little more than the theoretical amount should be used,

[3] Published in *J. Ind. Eng. Chem.*, 12, 145, 1920.

2.2 moles sodium hydroxide to 1 mole of sodium cymene sulfonate being sufficient. The presence of an appreciable amount of water in the fusion mixture tends to reduce somewhat the carvacrol yield. When water is added to the charge to the extent of 50 per cent. of the sodium hydroxide used, the fusion period should be increased to ten hours in order to secure the best yield.

The Revival of the Myth about Gunfire. SIR NAPIER SHAW. (*Quarterly Journal, Royal Meteorol. Soc.*, April, 1919.)—In an address before the Society its president says: "And, by way of parenthesis, it would seem that the Queen of the Air, the Goddess of Wisdom, according to the Greeks, sometimes makes merry at mortals' expense. During the war there was a good deal of arguing upon the time-honored subject of the influence of gunfire upon the weather. With the signing of the Armistice on November 11, 1918, there came a spell of calm fine weather, so that once more it became—shall I say apparent?—that with the cessation of gunfire came the repose of the elements, which, as some vigorous writers would have us believe, were under the control of our enemies' artillery. And then as the period of the Armistice went on and the guns, now mute, passed forward towards the East, like so many other things that have to do with the weather, there came upon us a succession of dismal dripping days, the like of which we may not wish to see again, but assuredly we shall, guns or no guns, if we live long enough; and once more we can assert that whatever else it may be that controls the weather, it certainly is not the absence of gunfire."

G. F. S.

The Lunar Tide in the Earth's Atmosphere. S. CHAPMAN. (*Quarterly Journal, Royal Meteorol. Soc.*)—From the time of Bernoulli and D'Alembert such tides have been considered. The author presents the results of a discussion of long series of records of barometric pressures from Batavia and Hongkong. The conclusions are: (*a*) The period of the lunar tide as shown in barometer readings is purely semidiurnal; (*b*) the amplitude of the variation in barometric reading is independent of the hour angle between sun and moon; (*c*) the data give no conclusive result as to the influence of the moon's distance; (*d*) there is a distinct seasonal variation affecting both amplitude and phase of the tide; (*e*) there is a rapid decrease of amplitude with departure from the equator.

At the equator the semi-amplitude of the lunar atmospheric tide is .084 millibars or .063 millimetres of mercury, which is 2.3 times as great as that predicted in Lamb's hydrodynamics.

G. F. S.

THE FRANKLIN INSTITUTE.

(Proceedings of the Stated Meeting held Wednesday, March 17, 1920.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 17, 1920.

PRESIDENT DR. WALTON CLARK *in the Chair.*

Additions to membership since last report, 7.

Reports of progress were presented by the Committee on Library and the Committee on Science and the Arts.

After the transaction of the above business the meeting became a joint one with the Philadelphia Section of the American Institute of Electrical Engineers, and the President requested Prof. C. E. Clewell, Chairman, to preside.

Mr. G. H. Clamer, of Philadelphia, presented the paper of the evening on "The Induction Electrical Furnace." The development of the induction furnace was traced, in its various forms, from its original conception by Colby of the single-turn, open-ring type furnace, to the latest developments by Dr. E. F. Northrup in the use of high frequency induction heating. The various fluid motions due to electro-dynamic forces were described, and the use which is made of such forces in several forms of induction furnaces was pointed out. Particular attention was given to the commercial operation of induction furnaces, using both low and high frequency currents. The subject was illustrated by numerous lantern slides. After a brief discussion a rising vote of thanks was extended to the speaker.

Adjourned.

R. B. OWENS,
Secretary.

COMMITTEE ON SCIENCE AND THE ARTS.

(Abstract of Proceedings of the Stated Meeting held Wednesday, March 3, 1920.)

HALL OF THE INSTITUTE,
PHILADELPHIA, March 3, 1920.

MR. CHARLES PENROSE *in the Chair.*

The following reports were presented for final action:

No. 2733. CO_2 and Draft Recorder. The Certificate of Merit awarded to Joseph W. Hays and Charles W. Hays, of Baltimore, Maryland.

No. 2742: Recording Devices. The Edward Longstreth Medal of Merit awarded to Morris E. Leeds, of Philadelphia.

No. 2755: The Franklin Medal Awards. The Franklin Medal awarded to Sir Charles Algernon Parsons and Prof. Svante August Arrhenius.

The following report was presented for first reading:

No. 2757-2758: Literature Award.

R. B. OWENS,
Secretary.

SECTIONS.

Mechanical and Engineering Section.—A meeting of the Section was held in the Hall of the Institute on Thursday evening, February 26, 1920, at 8 o'clock. In the absence of the Chairman of the Section, Dr. Walton Clark, President of the Institute, called the meeting to order. Major General C. C. Williams, Chief of Ordnance, U. S. Army, War Department, Washington, D. C., presented a communication entitled "Artillery of the A. E. F." A description was given of the various types of artillery equipment used by the American Expeditionary Force in France, with a brief discussion of their uses and the reasons for their adoption. The subject was illustrated by lantern photographs of guns and equipment used by the several allied forces.

After a brief discussion the thanks of the meeting were extended to the speaker.

Adjourned.

ALFRED RIGLING,
Acting Secretary.

Sections of Physics and Chemistry.—A meeting of the Section was held in the Hall of the Institute on Thursday evening, March 4, 1920, at 8 o'clock. The minutes of the joint meeting of February 5, were read and approved.

Henry S. Washington, Ph.D., Petrologist in the Geophysical Laboratory of the Carnegie Institution, Washington, D. C., delivered a lecture on "The Chemistry of the Earth's Crust." Among the subjects discussed were the homogeneity or heterogeneity of the earth's crust, the general quantitative occurrence of the various chemical elements in the crust, the average chemical composition of the igneous rocks, and their distribution in petrographic provinces. Attention was also paid to certain mutual relations between certain elements with special reference to the occurrence of ores and minerals, and the metabolism of plants and animals.

The communication was discussed by Drs. Kemp, Creighton, Keller, and Washington; Messrs. Quimby and Penrose, and others. On motion of Dr. Creighton, seconded by Mr. Penrose, a vote of thanks was tendered Dr. Washington. The meeting then adjourned.

JOSEPH S. HEPBURN,
Secretary.

Section of Physics and Chemistry.—A joint meeting of the Section and the Physics Club was held in the Hall of the Institute on Thursday evening, March 11, 1920, at 8 o'clock. Dr. George A. Hoadley on behalf of The

Franklin Institute, and Dr. Thomas D. Cope on behalf of the Physics Club, presided jointly. The minutes of the previous meeting were read and approved.

Dayton C. Miller, Sc.D., Professor of Physics in the Case School of Applied Science, Cleveland, Ohio, delivered a lecture on "Photographing Sound Waves from Large Guns and Projectiles." An account was given of an extended series of experiments conducted at several Proving Grounds, with the coöperation of the Ordnance Department of the United States Army, concerning the pressure, velocity and form of the sound-waves produced by the discharge of guns of large calibre, from 10 to 14 inches. The pressure field was studied by means of a new type of baroscope. The variation in the velocity of the explosive sound from the muzzle to a distance of several miles was determined by means of special microphones in connection with a string galvanometer and a recording device. A new portable phonodeik was used to photograph both the sound wave proper and the crack produced by the motion of the projectile. The lecture was illustrated by experiments and lantern slides.

The paper was discussed by Doctors Hoadley, Stradling, Miller and others. On motion of Dr. Walton Clark a vote of thanks was tendered Doctor Miller. The meeting then adjourned.

JOSEPH S. HEPBURN,
Secretary.

MEMBERSHIP NOTES.

ELECTIONS TO MEMBERSHIP.

(*Stated Meeting, Board of Managers, March 10, 1920.*)

RESIDENT.

MR. FRANCIS SHUNK BROWN, Lawyer, 1005 Morris Building, Philadelphia, Pa.

PROF. C. E. CLEWELL, Assistant Professor of Electrical Engnieering, University of Pennsylvania, and for mail, 4919 Osage Ave., Philadelphia, Pa.

MR. JACOB SCHORR, Production Manager, Greenwald Brothers, 9th and Spruce Sts., Philadelphia, Pa.

MR. IRA JEWELL WILLIAMS, Lawyer, 1005 Morris Building, Philadelphia, Pa.

PROF. WINTHROP ROBINS WRIGHT, Teacher, Department of Physics, Swarthmore College, and for mail, 4 Whittier Place, Swarthmore, Pa.

ASSOCIATE.

MR. JUSTO LOPEZ NAVARRO, Electrical Engineer, Philippine Engineering Co., and for mail, 121 L. Guerrero, Ermita, Manila, P. I.

MR. DAVID H. WILSON, Student, 640 North 32nd St., Philadelphia, Pa.

CHANGES OF ADDRESS.

COL. GEORGE H. EMERSON, Chief of Motive Power and Equipment, Baltimore and Ohio Railroad Company, Baltimore, Md.

MAJOR WILLIAM J. HAMMER, Hotel Earle, 103 Waverly Place, New York City, N. Y.

MR. FREDERIC V. HETZEL, P. O. Box 366, West Chester, Pa.
MR. R. L. O'DONNEL, Vice President, Pennsylvania Railroad Company, 903 Pennsylvania Station, Pittsburgh, Pa.
MR. H. R. VANDEVENTER, 206 Church Street, Sumter, S. C.

NECROLOGY.

Reuben Haines was born in Germantown, Philadelphia, in 1851, and died on February 18, 1920.

He was educated at Haverford College and the University of Pennsylvania, receiving from Haverford College the degrees of Bachelor of Arts in 1871 and Master of Arts in 1878.

Mr. Haines conducted a Chemical Laboratory for many years, and devoted considerable attention to water analysis. He was very active in the Chemical Section of the Institute, and contributed about a dozen articles to the JOURNAL, chiefly on water and water analysis. He also devoted considerable time to the subject of photography and collected a large number of negatives of places of historic interest near his home. He was a member of the American Chemical Society, the Society of Chemical Industry and a number of organizations devoted to the study of history and the natural sciences.

He became a member of the Institute in October, 1874.

Mr. Charles Abel, 300 Fifth Avenue, Haddon Heights, N. J.
Mr. C. M. Bunting, Comptroller, Pennsylvania R. R. Co., Broad Street Station, Philadelphia, Pa.

LIBRARY NOTES.

PURCHASES.

American Annual of Photography, vol. xxxiv. 1920.
American Society for Testing Materials.—Proceedings, vol. 19. 1919.
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Conversations on Chemistry.—2 vols. 1822.
DOOLEY, W. H.—Applied Science for Metal Workers. 1919.
HASKELL, A. C.—How to Make and Use Graphic Charts. 1919.
HIBBARD, H. D.—Manufacture and Use of Alloy Steels. 1919.
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Industrial Arts Index.—7th Annual Volume. 1918–1919.
MARKHAM, E. R.—Tool-Making. 1919.
MORRISON, L. H.—Oil Engines, Details and Operations. 1919.
MÜLLER, N. L.—Fabrikation und Eigenschaften der Metalldrahtlampen. 1914.
National Association of Cement Users.—Proceedings. Vol. xv. 1919.
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Photograms of the Year.—Annual Review. 1919.
Readers' Guide to Periodical Literature.—19th Annual. 1919.
RIDGWAY, ROBERT.—Color Standards and Color Nomenclature. 1912.
SMITH, J. R.—The World's Food Resources. 1919.
STRACHAN, JAMES.—Recovery and Re-manufacture of Waste Paper. 1918.

TINKLER, C. K., and CHALLENGER, F.—Chemistry of Petroleum and its Substitutes. 1919.

GIFTS.

Allis-Chalmers Manufacturing Company, Bulletin No. 1104. Milwaukee, Wis., 1919. (From the Company.)

American Cement Machine Company, Catalogue No. 920. Keokuk, Iowa., no date. (From the Company.)

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Amsterdam Koninklijke Akademie van Wetenschappen, Jaarboek, 1916; Proceedings of the Section of Sciences, vol. xix, parts 1 and 2, 1917; Verhandelingen Erste Sectie, Deel xxi, No. 3, 1917, Amsterdam. (From the Academy.)

Archer Iron Works Company, Catalogue No. 20. Chicago, Ill., no date. (From the Company.)

Austin-Western Road Machinery Company, Catalogue No. 18. Chicago, Ill., no date. (From the Company.)

Ballard, Frank E. Company, Catalogue of Automatic Pressure and Temperature Controlling Devices. Bridgeport, Conn., no date. (From the Company.)

Boston Pressed Metal Company, Catalogue, The Possibilities of Pressed Metal Engineering. Worcester, Mass., no date. (From the Company.)

Braun, C. F., Company, Catalogue "A." San Francisco, Cal., 1919. (From the Company.)

Canada Department of Mines, Summary Report for the year 1918. Ottawa, 1920. (From the Department.)

Canada Engineering Institute, Charter, By-Laws, List of Members, and Roll of Honour, 1919. Montreal. (From the Institute.)

Chicago Flexible Shaft Company, Catalogue No. 75. Chicago, Ill., no date. (From the Company.)

Coatesville Boiler Works, General Catalogue No. 24. Coatesville, Pa., no date. (From the Works.)

Colgate University, Annual Catalogue, 1919–1920. Hamilton, N. Y., 1920. (From the University.)

Columbus Bolt Works Company, Catalogue of Columbus Bolts and Nuts. Columbus, Ohio, 1919. (From the Company.)

Concrete Engineering Company, Handbook of Fieproof Construction. Omaha, Neb., no date. (From the Company.)

Condensite Company of America, Booklet No. 5, Bloomfield, N. J., 1917. (From the Company.)

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Crouse-Hinds Company, Catalogues Nos. 201 and 202. Syracuse, N. Y., 1917. (From the Company.)

Curtis Pneumatic Machinery Company, Catalogue No. 63. St. Louis, Mo., no date. (From the Company.)

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Edgemont Machine Company, Inc., Catalogue "G." Dayton, Ohio, no date. (From the Company.)

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Ferdinand, L. W., and Company, Booklet, Seaplane Float Construction. Boston, Mass., no date. (From the Company.)

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Friez, Julien P., and Sons, Catalogue B, Baltimare, Md., 1917. (From the Company.)

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General Electric Company, Catalogue Y-785-A. Schenectady, N. Y., 1919. (From the Company.)

Golden-Anderson Valve Specialty Company, Catalogue No. 20. Pittsburgh, Pa., no date. (From the Company.)

Herbert, Alfred, Ltd., Bulletin No. 51. New York, N. Y., 1919. (From the Company.)

Hergi Manufacturing Company, Bulletins Nos. 10 and 13. Bridgeport, Conn., no date. (From the Company.)

Huther Brothers Saw Manufacturing Co., Catalogue No. 38. Rochester, N. Y., 1917. (From the Company.)

Illinois Stoker Company, Catalogue "K." Alton, Ill., no date. (From the Company)

Institute of Metals, Journal vol. xxii, No. 2. London, England, 1919. (From the Institute.)

Inter-State Machine Products Company, Inc., Bulletin No. 500. Rochester, N. Y., 1919. (From the Company.)

Jones and Lamson Machine Company, Booklet, The Hartness Screw Thread Comparator for Accurate and Rapid Screw Gaging. Springfield, Vt., 1920. (From the Company.)

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Locke Insulator Manufacturing Company, The Insulator Book. Victor, N. Y., 1919. (From the Company.)

McKay, George C., and Company, Catalogue of the Automatic Electrical Screw Driver. Cleveland, Ohio, no date. (From the Company.)

Manchester Steam Users' Association, Memorandum for the year 1918-19. Manchester, England, 1919. (From the Association.)

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Ohio Brass Company, Catalogue No. 205. Mansfield, Ohio, 1919. (From the Company.)

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Richardson-Phenix Company, Catalogue of the No-Kut Pump Valve. Milwaukee, Wis., no date. (From the Company.)

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Skandia Pacific Oil Engine Company, Catalogue of Skandia Oil Engines. San Francisco, Cal., no date. (From the Company.)

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Standard Paint Company, Booklet, Preservative Coatings. New York, 1918. (From the Company.)

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University of Pittsburgh, General Catalogue 1918–1919. Pittsburgh, Pa., 1919. (From the University.)

Vassar College, Fifty-Fifth Annual Catalogue. 1919–1920. Poughkeepsie, N. Y., 1920. (From the College.)

Wagner Electric Manufacturing Company, Bulletin No. 120. St. Louis, Mo., 1919. (From the Company.)

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Wheeler Condenser and Engineering Company, Bulletin No. 112-B. Carteret, N. J., 1919. (From the Company.)

White, J. G., Company, Catalogue, Engineering on Foreign Fields. New York, 1916. (From the Company.)

Whiting Foundry and Equipment Company, Catalogues Nos. 149 and 150. Harvey, Ill., 1919. (From the Company.)

Wing, L. J., Manufacturing Company, Bulletin No. 58. New York City, N. Y., 1919. (From the Company.)

Wireless Specialty Apparatus Company, Catalogue of Radio Equipment. Boston, Mass., 1919. (From the Company.)

World Almanac and Encyclopedia, 1919, New York City, N. Y. (From Dr. Henry Leffmann.)

BOOK NOTICES.

ACCOUNTS RENDERED OF WORK DONE AND THINGS SEEN. By J. Y. Buchanan, M.A., F.R.S. 8vo, 435 pages, illustrated. Cambridge, at the University Press, 1919, New York, G. P. Putnam's Sons, price $6.75.

With a table of contents containing elaborate summaries of the several articles, and no index, this book is distinctly unconventional. It is, as the title indicates, a reprinting of essays and observations made by the author during many years of an active and useful life. His main interest is in oceanography. He is Commandeur de l'Order de St. Charles de Monaco. Most of the papers are supplemented by notes or appendices bringing the discussion up to date. All the articles make interesting reading. The versatility of the author will be clearly indicated by a summary of the several titles: Geography; its physical and economical relations (1889). A retrospect of oceanography in the twenty years before 1895 (1895). On similarities in the physical geography of the great oceans (1886). Relations of the temperature of the sea to that of the air above (1885). Color of the sea (1910). On the occurrence of sulphur in marine mud and nodules (1890). Note on manganese nodules found on the bed of the ocean (1877). Manganese nodules in Loch Fyne (1877). On the composition of oceanic and littoral nodules (1891). On a method of determining the specific gravity of soluble salts, etc. (1906). The Mediterranean Sea (reprint from 9th ed., *Encyc. Brit.*). On the composition of some deep sea deposits from the Mediterranean (1891). On the oxidation of ferrous salts (1881). The sunsets of autumn, 1883 (1883). Sur le densité et l'alcalinité des eaux de l'Atlantique et de la Méditerranée (1893). Monaco a whaling station (1896). The cruise of the *Princess Alice* (1902). The sperm whale and its food (1896). The oceanographic museum at Monaco (1910). Lakes (1882). On the distribution of temperature in Loch Lomond during the autumn of 1885 (1885). The winding of rivers (1907). Volcanoes and earthquakes (1872). On a remarkable effect produced by the momentary relief of great pressure (1903). Preliminary note of the compressibility of glass (1880). On the compressibility of solids (1904). On an apparatus for gas analysis (1874). Airtight subdivisions for ships (1889). The Northallerton accident (1894). The wreck of *Santos Dumont No. 6* (1902). The daintiness of the rat (1911). This paper gives an account of the peculiar selections of tissues of lemons and mandarin oranges by "forest rats" in a garden at Bordighera. The last paper is: On fish and drought (1911).

The book will furnish entertainment for many an hour to those interested in general science. It is well printed and numerously illustrated.

HENRY LEFFMANN.

TIDAL LANDS—A STUDY OF SHORE PROBLEMS. By Alfred C. Carey and Francis Wall Oliver. 248 pages, illustrations, 8vo. New York, D. Van Nostrand Company, 1919. Price, $5.00.

The Franklin Institute has recently acquired a copy of the above work, and in view of the destructive agencies which have been preying upon our coasts this work is a timely compendium, by experts, of the various efforts which have been made in foreign countries to protect riparian lands from those ceaseless physical forces. It is impossible to do justice to it in this brief notice, but the subject is treated in all its phases not only as a public utility, but from an engineering, botanical and physical aspect. Citations of failures and their causes are recorded as pointing the road to success—groynes, bulkheads, aprons, planting, drainage, etc., are carefully considered in relation to the local forces and requirements, with statements of costs.

In the United Kingdom the loss of foreshores amounted to 182,000 acres in 33 years—(5510 acres per annum or nearly 9 sq. miles). The same difficulties are recorded there as here in efforts to open channels through harbor bars, for it is said:

"As the sand travel has perplexed harbour authorities their traditional policy has been to push the entrance piers into deeper water as a means of eluding sand travel. Inevitably, as the piers are extended seawards, so the sand has crept out after (or before) them. The sum of the palliative measures may be stated thus: (1) To conserve and concentrate the tidal scour of the ebb tide; (2). To train the sea outfall; (3). To dredge."

This policy has been followed for many years in the United States, and yet the necessity for constant dredging continues and the bars rapidly advance so that jetties of from six to eight miles long, have failed to secure the necessary relief, but in one case at least of a tidal inlet, a portion of one breakwater was constructed across the bar, detached from shore, to admit the *flood tide freely*, which is a *sine qua non*, and it followed there was *no bar advance* and *no dredging was necessary* to secure and maintain the automatic channel thus created.

Much valuable data is recorded as to the plants most effective in restraining the travelling dunes driven by Aeolus and suggestive information as to State and Local jurisdiction which so frequently retards the urgent development of remedial measures. "Amongst these problems none takes precedence to that of national waterways and harbours." They are "the index of commercial progress." These and many other vital questions in physical and political economy are forcefully stated, and render this work of peculiar interest, in the welfare of national economy.

L. M. HAUPT.

TRAITÉ DE MÉCANIQUE RATIONELLE. By Paul Appel. 4th edition, entirely recast. Vol. i. 8vo. viii–602 pages and contents. Paris, Gauthier-Villars et Cie., 1919. 36 francs.

Besides improvements in many details and the addition of new bibliographic information, there has been added in the first chapter a dissertation on the theory of vectors. Three types of vectors are to be noted in practical application; unlocalised, gliding and localised. A distinction is also made between axial and polar vectors.

As an exercise on the movement of a point, there is presented a study of the simplest cases of movement of an electrifid particle, subjected to the action of superposed electric and magnetic fields, This study leads up to some interesting mathematical researches by Poincaré and Störmez, determined by the experiments of Birkeland and Villard and views expressed on the origin of polar auroras put forth by Birkeland and Arrhénius.

L.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS, Report No. 28. An Introduction to the Study of the Laws of Air Resistance of Aerofoils. Preprint from the Fourth Annual Report. 75 pages, illustrations, quarto. Washington, Government Printing Office, 1920. Copies may be obtained free from the Committee.

This report has been written for the purpose of giving a general survey of the present state of knowledge about the laws of air resistance of aerofoils.

A summary of the history of the subject and of the basis of the present-day treatment of the phenomena of fluid resistance is followed by a critical discussion of the fundamental concepts used to describe the fluid resistance properties of aerofoils. Thus are successively examined the concepts of angle of attack, centre of pressure, aerofoil area, metacenter, metacentric curve, zero lift line and resultant air resistance. First is examined the question of the apparent flow deflection produced by an aerofoil, preceded by a preliminary on the general property of vortices; the tip vortices are investigated; a general account on the intensity and direction of these vortices is given. Finally the edge vortices are studied and a general account of their properties is given, including the main qualitative relations that hold for these vortices. The possibility of formation behind an aerofoil of two waves, called the primary and secondary waves, is examined and numerical values of the order of their magnitude are given.

In a set of notes added to the report the following questions are examined: The Kutta theorem, the generalization of the Bernouilli theorem, the equations of the metacentric curves, as well as a translation of the paper of Th. v. Karman and H. Rubach on the Mechanism of Fluid Resistance.

Report No. 35. The strength of One-piece, Solid, Built-up, and Laminated Wood Airplane Wing Beams. Preprint from the Fourth Annual Report. 12 pages, illustrations, diagrams, quarto. Washington, Government Printing Office, 1919.

The purpose of this report was first, to determine by test the suitability of fir and cypress woods for airplane use, compared with Sitka spruce; second, to determine whether a plane rectangular I-section beam possessed any advantage over the oblique I-section beam, which is used at present, other than the advantage of simplicity in shop operation. The increased demand for Sitka spruce has made it necessary to look elsewhere for satisfactory woods that will meet airplane requirements. This report not only deals with experiments leading to the use of a perfectly satisfactory substitute for spruce, but also with the development of some method of construction which will conserve the present supply by utilizing more of the selected material. The tests included not only solid beams to determine their suitability as substitutes for spruce, but also beams built up of three pieces, or

of laminated construction, and tested to determine their strength in comparison with one-piece construction.

The built-up and laminated constructions eliminate the waste involved in the process of cutting the I-section from solid timber. In such construction it is also possible to use woods in short lengths, and though the cost of manufacturing built-up beams is somewhat greater than that of producing the solid beams, the cost of the raw material utilized is much less than the cost of the carefully selected timber used for solid beams.

Report No. 47. Power Characteristics of Fuels for Aircraft Engines. Preprint from the Fourth Annual Report. 35 pages, diagrams, quarto. Washington, Government Printing Office, 1920.

Early in the war the importance of securing the best possible fuel for aircraft engines led to the testing of twelve different gasolines in an aviation engine in the altitude chamber of the Bureau of Standards dynomometer laboratory. During the tests the engine was operated under conditions simulating those encountered in flight at altitudes up to 30,000 feet.

The results of this work, given in this Report, indicate no differences in excess of 5 per cent. in the maximum power developed by each gasoline when the carburetion was adjusted to each fuel. The question of economy is not considered in the report. Several physical properties of the fuels, including the distillation temperatures, were compared in an effort to identify those controlling the power producing ability, but no correlation was disclosed. R.

PUBLICATIONS RECEIVED.

Accounts Rendered of Work Done and Things Seen, by J. Y. Buchanan, M.A., F.R.S. 435 pages, illustrations, plates, tables, maps, 8vo. Cambridge, University Press; New York, G. P. Putnam's Sons, 1919. Price, $6.75.

Selling Your Services, by George Conover Pearson. 237 pages, 12mo. New York, Jordan-Goodwin Corporation. 1920.

Rätsel der Natur und Totengräber der Wahrheit, von Johannes Zacharias. 120 pages, illustrations, plates, portrait, 8vo. München, Johann Goebel, 1920. Price, 6 marks 16 pfennig.

Ontario Bureau of Mines: Twenty-eight annual report, 1919, Part I, 254 pages, illustrations, plates, maps, 8vo. Toronto, King's Printer, 1919.

U. S. Tariff Commission: Tariff Information Series No. 13. The Acids of Paragraph 1 and Related Materials Provided for in the Tariff Act of 1913. 85 pages, 8vo. Washington, Government Printing Office, 1920.

Canada Department of Mines, Mines Branch: Bulletin No. 27. Results of Forty-one Steaming Tests Conducted at the Fuel Testing Station, Ottawa, by John Blizard, B.Sc., and E. S. Malloch, B.Sc. 83 pages, diagrams, 8vo. Production of Iron and Steel in Canada During the Calendar Year 1918. 36 pages, 8vo. Ottawa, King's Printer, 1920.

U. S. Bureau of Mines: Technical Paper 232. Petroleum Technology 53. Absorption as Applied to Recovery of Gasoline Left in Residual Gas from Compression Plants, by W. P. Dykema and Roy O. Neal. 43 pages, illustrations, plates, diagrams, 8vo. Technical Paper 240. Boiler and Furnace Testing, prepared by Rufus T. Strohm. 23 pages, illustrations, 8vo. Washington, Government Printing Office, 1920.

CURRENT TOPICS.

Forest Products Laboratory, U. S. Department of Agriculture, Technical Notes.—This laboratory, at Madison, Wis., is engaged in the study of the properties and economic uses of woods. It has been giving especial attention lately to the application of wood in the construction of airplanes and as a source of paper.

Resistance of Airplane Parts to Decay.—This has now become of much practical importance. During the war, when the operation of a plane was liable to many interferences, the durability of the wood was of minor moment, but instances are now coming to notice in which replacements are needed in otherwise good conditioned planes, owing to decay. It appears that many woods are unsuitable for such use on account of lack of durability, but fortunately other woods of good quality are available. The best of these so far known is Port Orford cedar, after which come southern cypress and California redwood. Douglass fir, white oak and black walnut are fairly satisfactory. It is claimed that mahogany and Spanish cedar are also durable, but these have not yet been tested. Spruce which has been used so much in the United States is inferior in durability, and basswood, beech, birch and maple must also be classed with the inferior kinds. In all cases heartwood should be used. Preservative treatments may enable a somewhat less durable wood to be used if the better kinds are not available. Sodium fluoride may be used on parts that are to be glued, and so-called coal-tar creosote for parts not to be glued. Decay in struts, propellers and some other large members can be prevented by applying aluminum leaf.

Pulp Yield Reduced by Long Storage.—Comparative tests showed that while green wood yielded three and one-half tons per digester, the same wood after a year's storage yielded only three tons, and after two to three years the yield was only two and one-half tons. These losses are not compensated by any reduction in operative expenses, which indicates that the woodyard should be operated so that the material is used as nearly in rotation as possible.

Length of Wood Fibres.—The common opinion that each species of wood has a characteristic fibre-length is not borne out by the extended tests carried out by the Forest Products Laboratory. These measurements show that a greater difference may be found in the fibres from a given tree than between the average length in different species. No clearly defined relation has been found between the length of the fibre and the strength of the wood. The longer fibres are often found in the weakest material.

Resistance of Greenheart Timber to Marine Borers.—Six years

ago the laboratory placed specimens of this kind of timber in the Gulf of Mexico at points at which the water was much infested with several types of marine borers. A recent examination showed that with the exception of a slight trace of limnoria on the sapwood of one specimen, they were uninjured by either limnoria or xylotrya. All, however, had been severely attacked by pholas, which had made burrows from three-quarters to one and a half inches deep. It is not expected that the burrows will be materially deeper, as pholas does not make deep burrows, but the experiments show that if greenheart wood is used in such waters, the piles should be made large enough to allow for reduction in size by such attacks.

H. L.

Liquid Purification of Gases. (*The Gas Age* for February 25, 1920, vol. xlv, p. 161.)—LESTER M. GOLDSMITH describes an apparatus for removing sulphur from gases by using lime or ferric oxide in suspension in water, instead of the dry purifier, which has been so long a feature of the gas-producing plant. The latter has several objectionable features, among which are large area occupied, spare purifiers required for alternation, labor for renewing the beds and fire hazard. The water scrubber and cooler has never been developed seriously as a purifier, being only used as a secondary item. The Atlantic Refining Company after studying thoroughly all existing types of purifiers, decided that the dry purifier is unsuited for the treatment of large volumes of gas containing from 500 to 15,000 grains of sulphur per 100 cubic feet. It was decided to build an experimental plant of such form that it would be automatic, or nearly so, in operation, and involve a minimum outlay for space and labor. A suggested form of such a purifier was presented by H. Hodgson, of the United Gas Improvement Company. It consisted of two contact towers, one of wood and the other of steel, both with wood grids, the arrangement being such that the gas was passed in counter current to the liquid containing the purifying oxide in suspension, the liquid being subsequently pumped to a wooden tower in which it encountered a current of air to bring about revivification. Experiment showed that checker brick was superior to wooden grids for surface of contact, and therefore both towers were subsequently constructed of steel, filled with spiral brick checkered in symmetrical layers.

Numerous experiments were conducted and it was found that a suspension containing 3 per cent. of the iron oxide was most satisfactory. Trials with lime showed that this is more costly than iron oxide and the efficiency less. The paper is liberally illustrated by drawings of the installation and diagrams of its performance. Analysis of a sample of the iron oxide as delivered showed the presence of over 5 per cent. of combined sulphur and

about 3 per cent. of free sulphur. A sample of the exhausted oxide showed as follows in per cent. of total residue:

	Primary tower	Secondary tower
Free sulphur	88.9	39.3
Combined sulphur	0.52	1.74
Ferric oxide	6.79	30.76

The general conclusions from the experiments are:

1. In given apparatus under the same conditions there will remain a constant percentage of sulphur in the purified gas, whether the crude gas contained 10,000 grains per cubic foot or 1000 grains per cubic foot, and it is believed that this same relation will hold good with gases of lower sulphur content.

2. In any liquid purification plant built with two similar towers, passing the gas through in series, it can be expected that the first tower will remove 93 per cent. of the sulphur when the total purification is 95 per cent.; showing that the greater difficulty is encountered in removing the last traces of sulphur.

3. If the purifying liquid is maintained at a temperature between 90° and 100° F., the candle-power loss will be held down to a negligible quantity.

H. L.

Paint Manufacturers' Association of the United States has recently issued the following circulars through its Educational Bureau:

81. *Tuna Fish Oil.*—The gravity, iodine number, and saponification value of this oil were similar to the constants shown by linseed oil. The high iodine value (184) is of great interest, as it is really higher than that of most samples of linseed oil. Comparative drying tests proved that tuna oil dries even more rapidly than most grades of raw linseed oil. The excellent results obtained with this product indicate that the paint industry can utilize all that can be produced.

82. *Metre Equivalents.*—In this circular the value of the metric system is pointed out for use in export trade. Comparative information is given regarding the contents of the United States liquid gallon, the British imperial gallon, and the metric measures of like capacity. All the equivalents in metric and United States units of measure are given, including length, mass and capacity.

83. *Hexabromide Tests for Determining the Purity of Soya Bean Oil and Linseed Oil.*—Two methods are given for determining the hexabromide value of linseed oil. Since linseed oil has a hexabromide value of approximately 44, whereas soya bean oil has a value of only 5, it is possible by this novel method to detect soya bean oil in linseed oil, heretofore impossible by any other analytical method.

84. *Standards for Tung Oil.*—The method recommended is a modified form of the Browne method, and an illustration appears of the apparatus that is used. It is probable that this method gives more concordant results than any other existing method. The circular also discusses the Agnew open-pan heat test method for determining the purity of tung oil.

85. *Oil Absorption of Pigments.*—This circular is probably one of the most important issued by the Educational Bureau during the year. It presents a method of determining the oil absorption value of different pigments and points out the difference between absorption and adsorption. It presents data showing the oil absorption value of several different pigments in different types of liquids. A full description of the apparatus required, method of procedure, etc., for running the tests, is given.

86. *Yellow Tail Fish Oil.*—The results of an examination of yellow tail fish oil obtained on the west coast through the Bureau of Fisheries are presented. The constants are similar to those given by linseed oil. In the comparative drying tests described yellow tail fish oil gave results almost as satisfactory as linseed oil.

87. *A New Method of Determining the Acid Value of Varnished and Boiled Oils.*—A method is presented for determining the real acid value of varnishes, boiled and bodied oils. The old method of using alcohol gives erroneous results where the liquids to be examined are colloidal. It is further shown that through the use of a mixture of alcohol and benzene the colloidal condition is broken down and true solution of the acids brought about, so that accurate results may be obtained.

H. L.

Forest Products Laboratory Technical Notes, Madison, Wis.

Tearing Strength of Paper.—There is no relation between the actual toughness of paper and the values obtained by the commonly used testing machines. Employing a Schopper tensile machine it was found that the toughness can be numerically rated, but that the breaking length, percentage stretch and number of folds give very little information about this property. Figures are given for results on different types of commercial paper, showing the correctness of the general statement above made. (Circular 97.)

Fuel Value of Wood.—Two pounds of dry wood of any non-resinous species have about the same heating value as a pound of good coal. A ton of coal may be taken as equivalent to one cord of heavy wood, one and a half cords of medium weight, or two cords of light wood. Resin gives twice as much heat as wood, weight for weight, hence pines firs have a much higher heating power than the non-resinous forms. The resin content is considered to be about 15 per cent. The fuel value of wood,

however, depends upon several other properties than the calories, such as easy ignition, rapid burning, and smokeless and uniform heat. As a rule, soft wood burns more readily than hard and light more readily than heavy. Pines give quick, hot fires, but oak gives a steady heat. (Circular 98.) H. L.

An Absorbent for Carbon Monoxide. (*Jour. Ind. and Eng. Chem.*, 1920, v. 12.)—Hopcalite is a new compound for removing the carbon monoxide, a deadly gas, from the air in places where workmen are exposed to its effects.

Carbon monoxide is the poisonous constituent of illuminating gas and is responsible for the deaths of persons who inhale the fumes from gas jets. The use of an adequate filter in gas masks would be of great value to firemen and others entering a room in which there is free illuminating gas. The carbon monoxide also appears in the fumes from automobiles which sometimes overcome workmen in repair shops and garages.

Hopcalite was devised originally for use as a filter in the army gas masks, and the experiments which led to its development were kept under the seal of military secrecy. An account of them is now published for the first time in the current number of the *Journal of Industrial and Engineering Chemistry* of the American Chemical Society, as a contribution from the Chemical Warfare Service. The publication is authorized by the Director of the United States Bureau of Mines and by the Director of the Chemical Warfare Service. The authors of the paper are Arthur B. Lamb, William C. Bray and J. C. W. Frazer.

Carbon monoxide is so harmful that at one time it was considered as a poison gas for use in war. Although it was found to be unavailable for intentional use, it was a factor none the less in a military sense, when it gathered in confined spaces.

"In one of the naval engagements between the Germans and the English," to quote from the paper, "defective high explosive shells, after penetrating into inclosed portions of ships, evolved large quantities of carbon monoxide and thus killed some hundreds of men. On shore, machine gun fire in inclosed places such as pill boxes and tanks liberates relatively large portions of carbon monoxide and has been responsible for numerous casualties. Similarly in mining and sapping work, the carbon monoxide liberated from the detonation of high explosives constitutes one of the most serious of the difficulties connected with this work, and has necessitated elaborate equipment and extensive military training in mines rescue work.

"Carbon monoxide is also a serious hazard in peace as well as in war. In the manufacture of power and illuminating gas, and in the metal industries where this gas is largely employed, casualties and indeed fatalities are constantly occurring. In coal mining, in certain classes of copper mining and wherever explosives are used

in confined spaces, carbon monoxide is a serious menace responsible for the loss of many lives each year. Leaky flues, exhaust gases from explosive engines, improper ventilation where coal fires are employed and the air to which firemen are exposed to burning buildings all constantly take a not inconsiderable toll of human lives."

So important is the fight against carbon monoxide regarded in the future, that special investigations have been begun lately to determine the best means of combating it in spaces where automobiles are moving under conditions where there is little ventilation. Thirteen students of Yale University recently volunteered to submit themselves to tests, to determine how much of the gas the human system could tolerate when mixed with air. The proposed experiment was suggested by the plans for the huge vehicular tunnel under the Hudson River which is to connect New York City and New Jersey. Through it will be moved many automobiles and power trucks at different levels, and the carbon monoxide factor is considered a strong one in planning systems of ventilation for the colossal bore.

The research which resulted in the development of hopcalite began at the University of California. The group of investigators were transferred to a station at the American University, at Washington, D. C., and Washington and Baltimore laboratories worked in collaboration. The Hopcalite first made consisted of a mixture of fifty per cent. manganese dioxide, thirty per cent. of copper oxide, fifteen per cent. of cobalt dioxide and five per cent. of silver oxide. Minor modifications have since been made in the process.

It was ascertained that this mixture placed in an ordinary gas mask canister worked very well. Its usefulness, however, is gradually impaired by the absorption of moisture. This danger point can readily be determined by weighing the canister from time to time and discarding the mixture when its weight reaches a certain weight.

Recent Investigations on Milk and Butter.—G. C. SUPPLEE, in a thesis published by the *Cornell University Experiment Station*, presents the results of studies to determine the lecithin content of butter and its relation to the fishy flavor occasionally observed which reduces its commercial value, although it may have no sanitary significance. After a discussion of the literature, the author sets forth data derived from a careful study of the lecithin content of many samples of butter, as there appear to be no reports on this question. It was found that lecithin in appreciable quantities could be obtained and identified by appropriate tests. Quantitative determinations were made on butter made from cream respectively raw and ripe, pasteurized and sweet. In all these notable amounts of lecithin were found. Ripened cream seems to yield a butter with a less lecithin content than the raw cream. Confirmative reaction was obtained by the production of choline periodide, the crystals of which are distinct and of which photmicrographs are

shown. The final conclusion of the investigation is that the fishy odor is due to small quantities of trimethylamine produced by the decomposition of the lecithin. A definite acid condition is essential to the development of the fishy flavor, and is most likely to be produced when butter is made from cream containing lactic acid, whether this latter is produced by fermentation or by direct addition, but some strictly biologic condition must also exist.

H. L.

The Food Value of Milk is discussed at length and from the results of many experiments by Edna L. Ferry in Bull. 215, Dec., 1919, of the Connecticut Agric. Exper. Sta. The following are the principal points established:

Milk is absolutely essential for the young, is a desirable addition to the diet of adults, and the main reliance in many cases of disease. Milk is especially adapted to supplement the protein deficiencies of the cereals which constitute so large a part of human food, in addition to which its content of the three so-called "vitamins," makes it almost indispensable for "growing" animals, but it is not yet proved that they are all essential to maintaining health in well-developed adults. One of the vitamins—known provisionally as the scurvy-preventing form—is destroyed by heat, and therefore, it is to be inferred that for infants fed on pasteurized or sterilized milk, some other food, such as orange juice, containing this vitamin should be liberally used. The investigator declares that milk at 16 cents a quart is a cheaper food than beef at 35 cents a pound or eggs at 35 cents a dozen. H. L.

Liquid Oxygen and its Application as an Explosive in Mining. R. PAPST. (*Zeit. Ver. Deutscher Ing.*, Jan. 3, 1920.)—According to this book review the use of liquid oxygen as an explosive acquired considerable vogue in Germany during the war. Indeed the members of The Franklin Institute saw pictures of certain phases of its use in the thoughtful destruction of French industrial plants upon the occasion of the lecture of Mr. George S. Rice on November 19, 1919.

Since 1914 the "Sprengluftgesellschaft" has made great progress in the handling of liquid air. The kernel of the matter lies in the production of special vacuum vessels in which the liquid can be shipped and in which it will remain at −180° C.

It is possible to produce on a wholesale scale cartridges of long life and of a wide range of explosive properties. The difficulty of having the fuse at the very low temperature of the liquid air has been overcome. A great advantage of this type of explosive is its harmless character so long as the cartridge and the liquid air are not in intimate contact.

The suggestion is made that land can be cleared of stumps at a cost of about 4 marks per square meter. G. F. S.

The Recent Eclipse Results and Stokes-Planck's Aether. L. SILBERSTEIN, Univ. of Rome. (*Phil. Mag.*, Feb., 1920.)—In 1845 Sir G. G. Stokes proposed a theory of aberration in which the ether at the earth's surface was supposed to be dragged along with the earth and at the same velocity. The dragging effect grew less as the distance from the earth increased, until it ceased entirely and the ether had no motion imparted to it by reason of the earth's motion. Later Planck added the important detail that the ether is condensed near bodies such as the earth which have the force of gravitation.

Prof. Silberstein believes that this theory accounts for the aberration of light, "for the older terrestrial optical nil-effects," "also for the nil-effect of the Michelson-Morley experiment." "The bending of rays of light round the more massive terrestrial bodies would be only a by-product of the theory." This rival to the Einstein theory thus accounts for the bending of the rays of light from stars when the path is close to the sun as was observed to be the case at the solar eclipse of 1919. It does not, however, carry with it as a consequence that there should be a shift in the lines of the spectrum as does the Einstein theory. This shift is "obstinately absent," yet, on the other hand, in *Nature*, Jan. 29, 1920, is cited a passage from a letter coming from Einstein in which he says that two young physicians in Bonn have as good as proved the existence of the displacement effect in the spectrum lines.

G. F. S.

Glues Used in Airplane Parts. (*Report 66, National Advisory Committee for Aeronautics.*)—This report compiled by S. W. Allen and T. R. Truax, of the Forest Products Laboratory, U. S. Dep't Agriculture, gives a large amount of information on the composition and efficiency of the many forms of glue that have been tried out with the airplanes. Brief accounts are given of the glues, and a classification of them, a classification that is somewhat arbitrary, probably for strictly practical reasons, as a distinction is made between "animal" glues and "liquid" glues, although both kinds are prepared from animal tissues. Vegetable glues are generally made from starch, the cassava being the usual source. Casein glues contain casein mixed with lime and other ingredients. Blood-albumin glues are usually sold in powdered form and when dissolved must be used promptly, being very liable to decomposition. Descriptions are given of the standard methods of manufacturing of all these forms of glues, the precautions to be taken in applying them, and a bibliography of each type. In comparing the efficiency of the different types, ordinary animal glue, on account of its long use and familiarity to all wood-workers, is taken as the standard. This form has some very desirable properties, among which are great strength and reliability in the higher grades, free flowing and the fact that it does not cause staining in fancy veneers. So far no

substitute has been found for this glue for hand-spreading on irregular joints. The price of the article and the fact that it is not water-resistant are the chief factors that limit its use. Casein glue has high water-resistance, is easily spread, strong and can be used cold, but it stains veneers, and some forms have short working life. Vegetable glues have found extensive use in recent years on account of their cheapness. They also may be used cold and remain in good working conditions for many days, but are very viscous, cannot be spread by hand, are not water-resistant and usually cause staining in thin veneers. Blood-albumin glue has notably high resistance to moisture, especially in the boiling test, which makes it useful in cementing plywood that is afterwards to be softened in hot water and molded. It is possible to make very cheap glues of this type. The drawbacks to blood-albumin glue are the expensive apparatus required, the relatively low production and the fact that it is not very suitable for gluing thick stock.

Liquid glues are in general similar to the standard animal glue, but the commercial forms are not uniform, some being quite strong and others weak. Their great advantage is that they come ready for use, which makes them suitable for patch-work and small jobs. The high price, low water-resistance and difficulty in distinguishing between good and bad brands are serious drawbacks. Several pages are devoted to summarizing the testing methods and results.

H. L.

The Mechanism of the Addition of Hydrogen to Unsaturated Glycerides in the Presence of Finely-Divided Nickel has been studied by R. THOMAS (*Journal of the Society of Chemical Industry*, 1920, xxxix, Transactions, pp. 10–18). The more highly unsaturated glyceride linolin added hydrogen at a very considerably greater rate than did the less unsaturated glyceride olein. The hydrogen apparently becomes active by absorption in the nickel, which plays the part of a catalyst, and is dissociated from molecules into atoms. The olein is brought into an active condition by infrared rays emitted by the catalyst; and the reaction is photochemical in nature. Gaseous catalyst poisons may act in a purely physical manner, or may act in a chemical manner, either reacting in the presence of the catalyst *e.g.* carbon monoxide, or combining with the catalyst, *e.g.* hydrogen sulphide. J. S. H.

Industrial Research.—In a bulletin of ARTHUR D. LITTLE, INC. (Bibliographic Series No. 3), entitled "A Reading List on Industrial Research," by West and Greenman, Dr. Little writes an introduction in which he says among other statements: "Within a professional experience of more than thirty years nothing has been so striking as the sudden recognition of the fundamental importance of research, by governments, leaders of industry, and the man in the street, during the progress of the war. The war itself has been

characterized as a chemist's war, and chemistry has permeated every aspect of it. The chemists of all the belligerent countries have been organized into the equivalent of what we have termed the Chemical Warfare Service, and for the time, to which we may now happily refer in the past tense, the entire chemical brain and energy of each combatant nation was engaged in the solution of problems of offense and defense." A single producer found it necessary to employ a thousand chemists. "Thus," adds Dr. Little, "it has become the duty and the privilege of those of us who are familiar with this method and its application to preach the Gospel of Research."

H. L.

Digestibility of Certain Miscellaneous Vegetable Fats.—ARTHUR D. HOLMES and HARRY J. DENEL, JR., have found that the digestibility coefficient of fats, which have melting points above body temperature, varies inversely with the melting point. The tolerence of a fat by the human body governs its use in the dietary. In the present paper (*Journal of Biological Chemistry*, 1920, XLI, 227–235), these investigators have studied the digestibility of certain less commonly used fats, which may be of value in times of shortage of the more common fats. The fat of the avocado fruit is 87.9 per cent. digestible. Cohune oil, derived from the kernel of the cohune palm, *Attalea cohune*, of Central America, is 99.1 per cent. digestible. Cupuassú fat, which is expressed from the seeds of the cupuassú tree of Brazil, is 94.1 per cent. digestible. Hemp seed oil is 98.5 per cent. digestible. Palm kernel oil is pressed from the interior portion of the kernels of the fruit of the African palm tree, *Elaesis guineensis;* it is 98.0 per cent. digestible. Poppy seed oil, which is produced in the Orient and is used as an edible oil in Europe, is 96.3 per cent. digestible. These oils and fats exerted no unusual effect on the utilization of the protein and the carbohydrate in the diet; none of them produced any abnormal physiological effect except cupuassú fat, which caused slight disturbances.

J. S. H.

Industrial Uses for the Shark and Porpoise are enumerated by Dr. ALLEN ROGERS, in the *Journal of the Society of Chemical Industry*, 1920, xxxix, Transactions, pp. 9–10. The sharks are caught in nets. The fins are removed, dried in the sun, and sold to Chinese as an ingredient for soups. The skins are removed, fleshed by machines, pickled in salt and sulphuric acid, and finally submitted to tanning processes to obtain either bag leather or shoe leather. The flesh and bones are ground, then dried in a rotary dryer to obtain a fish scrap fertilizer which contains from 15 to 17 per cent. of nitrogen calculated as ammonia. The livers are allowed to disintegrate for several days, then are heated to boiling for approximately one hour in steam-jacketed kettles to remove the oil, which

is purified by washing and settling. Porpoises are caught and utilized in a similar fashion; however, the blubber and the jaw oil are collected and used separately for the manufacture of oils. The flesh of both sharks and porpoises is edible, and should serve as a source of food for man.

J. S. H.

Army Ration.—DR. MERKEL H. JACOBS, Captain, Sanitary Corps, United States Army, has studied the army ration and its balance (*Military Surgeon*, 1919, xliv, 600–616). Under ordinary conditions, a soldier eats sufficient food to obtain, on the average, from 3200 to 4000 calories daily. In a permanent camp his average daily food consumption is 3600 calories, including 1200 calories at breakfast, 1300 calories at dinner, and 1100 calories at supper; 110 grams of protein or nitrogenous food and 97 grams of fat are eaten daily; the remainder of the energy is supplied by starches and sugars in the foodstuffs. A deviation of 200 or 300 calories from the average is permissible on some days provided the general average be maintained.

J. S. H.

Carotinoids as Fat-Soluble Vitamine.—The provisional assumption has been made that the fat-soluble vitamine is identical with one of the carotinoids or pigments of the fats. PALMER (*Science*, 1919, l, 501–502) points out that the fat-soluble vitamine may occur in nature in the absence of carotinoids, and that carotinoids may occur in nature and the absence of the fat-soluble vitamine. Thus, fresh cotton-seed oil contains carotinoids but no fat-soluble vitamine; the milk fat of certain animals contains fat-soluble vitamine but no carotinoid. Therefore the fat-soluble vitamine cannot be identical with a carotinoid pigment.

J. S. H.

Longevity of Bacteria in Bottled Commercial Spring Water.—MAUD MASON, Obst. (*Journal of the American Pharmaceutical Association*, 1919, viii, 735–745), concludes that water can be stored in bottles so that contamination will not enter. When a stored bottled water is re-examined within a period of 30 days, the two analyses may or may not yield the same bacterial count; but *B. coli*, whose presence indicates fecal pollution, will probably not increase during the interval between the analyses. Even after storage for 3 years, pollution can be detected in a bottled water; such water may not be used with safety for drinking purposes. Apparently certain salts favor, and other salts are antagonistic to, the longevity of bacteria in commercial waters. The presence of moulds in large numbers in a bottled water suggests storage. In the presence of water bacteria, *B. coli* may live in bottled spring waters for several years; it is not safe to assert that *B. typhosus*

(the organism of typhoid fever) and other members of this group of bacteria will not survive long periods of storage under similar conditions. When pure cultures of *B. coli.*, *B. typhosus*, and *B. dysenteriæ* (the organism of bacillary dysentery) were introduced into sterilized, bottle spring waters, these organisms did not multiply; in fact they underwent a steady decrease in number. However, *B. dysenteriæ* was recovered alive from 3 such waters 4 or 5 days after inoculation; and *B. typhosus* was recovered alive from a water which had been stored for 2 months after inoculation.

J. S. H.

Specific Heat of Liquid Hydrogen and of Solid Hydrogen. Heat of Fusion of Hydrogen. W. H. KEESOM and H. KAMERLINGH ONNES. (*Communications from the Physical Laboratory of the University of Leiden.*)—Liquid Hydrogen. The calorimeter was jacketed with solid hydrogen. Heat was applied to the liquid, whose temperature ranged from 15 to 20 degrees absolute, by means of an electric current. The values of the specific heat varied from 1.67 to 2.18 calories per gram.

Solid Hydrogen. The results are merely preliminary. The values of the specific range from .45 to .73. Thus the product of the specific heat of hydrogen by its atomic weight (atomic heat) is only a small part of the value which other solid elements have for this quantity. It is noticed that hydrogen like water has a smaller specific heat in the solid than in the liquid phase.

Heat of Fusion. A mean value of 15 calories per gram is given as the result.

G. F. S.

Annual Physical Society and Optical Society Exhibition. London. (*Electrician*, Jan. 16, 1920.)—The last previous exhibit of the Physical Society was held in 1913. The Admiralty and the Air Ministry displayed instruments captured from the Germans, mostly of an optical character and of surprisingly crude workmanship.

One especially interesting exhibit was an electrical CO_2 recorder to measure the percentage of this gas in flue gases. Two exactly similar spirals of platinum wire are supported in similar holes in a copper block and are made two arms of a Wheatstone Bridge, which is then balanced so that the galvanometer shows no deflection. While the same current flows through both spirals, they lose heat equally and remain at the same temperature, provided they are surrounded with the same gas. If one, however, is surrounded by air while the other has flue gas around it, the heat loss will be different and by consequence the temperatures of the spirals and the electrical resistances will differ. This destroys the balance of the bridge and the galvanometer deflects. From the amount of the deflection the percentage of CO_2 is inferred, in fact the galvanometer records directly upon a chart from which percentages can at once be read.

G. F. S.

American Pulp-Woods.—The Forest Products Laboratory of the U. S. Dep't of Agriculture has reprinted as a bulletin a collection of data (originally appearing in *Paper*, July 30, 1919) concerning the American woods that may be available as sources of paper-pulp. The great demand for paper has brought about investigations for new sources. The experiments were made in semi-commercial digestors carrying about 100 pounds of material. It was found that the general cooking conditions, yield, bleach consumption and other points as derived from the experimental plant compare satisfactorily with results obtained on the large scale. The publication gives detailed information as to the suitability of about two score American trees, mostly in relation to the sulphate, sulphite and mechanical processes, but a few also for soda-pulp. With each tree is given the approximate distribution, the scientific and common names, the yield under the different methods, the physical qualities of the pulp and the most likely use that can be made of it in the paper trade. There is a great range of applicability noted. The experiments have been going on for ten years.

H. L.

Production of Alcohol from Sulphite Liquors. (*Bibliographic series No. 2*, ARTHUR D. LITTLE, INC.)—This is a bibliography of a little over one hundred items on the literature of the manufacture of alcohol, principally ethyl from the waste liquor of sulphite pulp works. This highly objectionable waste has been the subject of extensive studies with a view to find some use for it that will make its utilization reasonably profitable. The list was prepared by Clarence D. West. The items are arranged by authors alphabetically. It might be a better plan to arrange them chronologically. The extent of the bibliography shows the interest that attaches to this subject.

H. L.

Effect of Light on Glue. (*Aircraft Technical Note, Bureau of Construction and Repair, Navy Department.*)—LIEUT. GARDNER, U.S.N.R.F., reports that inquiries having been made as to the possible effect of ultra-violet light on glue used in laminated wood construction, investigations have been started, though the impression is that the effect will be slight. The basis of the inquiry is probably the general opinion that the intensity of the ultra-violet light increases with altitude, owing to the less absorption by the atmosphere. It is noted that the older method of finishing plywood with varnish would not protect the glue, but the department now uses a gray enamel which is practically opaque to light rays.

Veneer Tests.—In the bulletin above quoted, the experiments of the Forest Products Laboratory with several types of glues used in fastening veneers are recorded. Panels suitably prepared were

exposed to the action of fresh and salt water, gasoline and engine oil, boiling and soaking and to differing conditions of atmospheric humidity. Fresh and salt water seemed to have about equal effect. Glued panels that resist eight hours' boiling, followed by subsequent drying, will also stand twenty-four hours' baking. For inspection purposes the boiling has been limited to eight hours, which is equivalent to a ten days' soaking test. Panels that pass this test will stand much exposure to atmospheric humidity.

H. L.

Prevention of Dope Poisoning. (*Aircraft Technical Note, Bureau of Construction and Repair, Navy Department.*)—Workmen who apply the dopes to wing fabrics find often serious skin troubles on the hands. It has been found possible to eliminate much of this difficulty by using vaseline, glycerol or similar emollients rubbed well on the hands before beginning work. The dried dope does not then adhere firmly to the skin and can be removed by rubbing in a further portion of the emollient and washing with soap and water. An application of vaseline to the cleaned surface is beneficial. Dopes containing tetrachlorethane, which is volatile, cause pronounced jaundice to those much exposed to the vapors of it, and this solvent is, therefore, not approved by the Navy Department. The solvents now used are not strongly toxic, but in all such work active ventilation should be maintained.

H. L.

Royal Belgian Academy, Section of Sciences. (*Bull. Classe des Sciences,* 1919, p. 158.)—Formally decided to sever relations and to cease the exchange of publications with the learned societies of Germany, Austria, Hungary, Bulgaria and Turkey, to send no publications to the savants of these nations, to refuse to receive and to return such publications as should be sent to the Academy by authors or societies in the five enemy countries and to employ the usual channels of commerce to purchase such publications as seem strictly essential. G. F. S.

Thermostat for Low Temperatures. P. BRUYLANTS and W. MUND. (*Bull. Classe. des Sciences. Acad. Roy. de Belgique,* 1919, p. 113.)—The boiling of a pure liquid under a constant pressure furnishes a fixed temperature and is especially applicable when rather high temperatures are desired. The melting of pure solids in contact with their liquids gives another method, but the presence of a small quantity of impurity makes quite a difference in the melting point. The authors employ the constancy of temperature at which cryohydrates solidify. Cryohydrates are solutions of salts in water of such strength that they are saturated at the temperature at which solidification occurs. The resulting solid therefore is composed of both solvent and solute and the unfrozen part of the liquid remains

saturated as at the beginning of freezing. A table of cryohydrates is given whose temperatures of solidification range from –62° to –2.9° C. For instance, 42.5 gr. calcium chloride in 100 gr. water solidifies at –55°.

A large Dewar bulb, filled with alcohol or ether, contained a cylindrical vessel enclosing the cryohydrate (eutectic). The constancy of temperature was such that in one case the change in an hour and a half amounted to only .03°, while the largest change was .07° in four or five minutes.

A disadvantage is the likelihood of the solidification of the cryohydrate causing the breaking of vessels immersed in it.

The article bears the date July, 1914, Louvain—a month before the town fell into the hands of the Germans.

G. F. S.

The Measurement of Magnetic Susceptibilities of Low Order. ERNEST WILSON. (*Proc. Royal Soc.*, A680 Feb., 1920.)—In connection with the new magnetic survey of the British Isles it was found desirable to have a convenient instrument for the measurement of low magnetic susceptibilities such as those of granite and other rocks. The principle of the Curie balance was employed, that is, the specimen under examination was suspended from a torsion thread so that it rested within the air gap of a ring electro-magnet. When a current flows through the coils of the magnet the specimen is deflected and the angle is determined by a mirror. The susceptibility per unit volume is calculated in a simple manner from this deflection, the number of amperes of current and a constant of the instrument.

The instrument can be used to investigate the magnetic properties of powders and of liquids. It promises to furnish a rapid method for determining the relative amounts of ferrous iron in different specimens of glass. Mica was found to have fifty times as great a susceptibility parallel to the laminate as perpendicular to them.

G. F. S.

Bituminous Coal Industry. (*U. S. Geological Survery Press Bulletin*, No. 439, February, 1920.)—At the February meeting of the American Institute of Mining and Metallurgical Engineers in New York the afternoon session on Tuesday, February 17, was devoted to a discussion of the bituminous-coal industry. The fluctuations in production and their extent and causes were discussed in a paper by George Otis Smith, Director of the United States Geological Survey, Department of the Interior, and F. G. Tryon, the coal statistician of the Survey. The statistical facts collected by the Survey during the last 30 years were graphically set forth in a dozen diagrams and certain broad conclusions were drawn from these facts.

The "bad load factor" of the soft-coal mines of the country shows itself in the annual, seasonal, and daily fluctuations in coal

production. On the average, during the past 30 years the mines have been idle 93 working days in the year.

The national interest in bettering the load factor of the soft-coal industry is measured by the fact that we have an excess mine capacity of at least 150 million tons and an excess labor force of perhaps 150,000 men. In terms of man-days, universal military training of our young men for three months would cost the nation less than the present enforced idleness in coal mining.

Chromite Production, 1918. (*U. S. Geological Survey Press Bulletin*, No. 438.)—In view of the record-breaking production of chromite in the United States in 1918, reported by the United States Geological Survey, Department of the Interior, it is of interest to note the part it played in the world's output for that year. The approximate output in round numbers for each country is expressed below in metric tons.

WORLD'S PRODUCTION OF CHROMITE IN 1918.

United States	84,000
Canada	20,000
Cuba	9,000
Guatemala	1,200
Brazil	18,000
British South Africa	28,000
Turkey (Asia Minor)	14,000
Greece	10,000
Austria-Hungary	500
Russia	16,000
India	20,000
Australia	800
New Caledonia	26,000
Japan	8,000

Recent Advances in the Utilization of Water Power. E. M. BERGSTROM. (*Electrician*, Feb. 6, 1920.)—"The outstanding features in the development of the utilization of waterpower can be summarized as follows:

1. The exclusive use of two types of turbines only, namely, Francis reaction turbines for low and medium heads, and Pelton impulse wheels for high heads.

2. The extension of the use of Francis turbines under heads approaching 800 feet, and Pelton wheels in single stage up to 5500 feet.

3. The exclusive adoption of balanced wicket-gates for regulation of Francis turbines and the circular nozzle with combined deflector and needle regulation for Pelton wheels.

4. The standardization of turbine runners and increased specific speed permitting the use of single vertical units of large output under low heads.

5. The general increase of output per unit, the maximum output at present being 31,200 B.H.P.

6. The general increase of the over-all efficiency of about 6 to 10 per cent.

7. The exclusive use of oil-pressure governors.

8. The efficient regulation (by means of differential surge-tanks) of turbines using long pipe lines.

9. The employment of large diameter pipe-lines under high heads, resulting in an appreciable reduction of the initial cost of development." G. F. S.

New Wireless Phone Carries 900 Miles. (*Jour. Am. Inst. Elec. Eng.*, Feb., 1920.)—Wireless telephone conversations have been carried on between Ossining, N. Y., and Chicago over a distance of 900 miles with a power of one-third of a kilowatt. The wave length used was 375 metres. Wireless telegraph operators in Ohio, South Carolina, Massachusetts and Chicago while listening for dots and dashes heard a voice instead of what they were expecting. G. F. S.

Aluminum-dust Explosions.—The phenomena of explosion seem to involve some very peculiar actions. With the better known explosives, such as gunpowder, guncotton and the more recently invented benzene derivatives, the effects are not difficult to understand as they are dependent on the productions of large volumes of hot gas, of high critical points. With many other forms of explosive, however, this explanation does not apply. A minute amount of mixture of potassium chlorate and phosphorus will produce a startling rending effect, and a few grains of sulphur triturated with potassium chlorate will often break a thick-walled Wedgewood mortar, although the hand holding the same is not injured. In these cases we can hardly assume the production of any notable amount of gas.

In a recent number of this JOURNAL an abstract was given of a report on starch-dust explosions from the Bureau of Mines, it being stated that the explosion was unexpectedly violent, exceeding greatly those produced by coal dust and flour. In *Technical Paper 152* of the same bureau, Alan Leighton presents interesting data in regard to explosions of aluminum dust. This material now extensively used in the manufacture of a metallic paint, burns quietly when a small heap of it is ignited, but if distributed through a confined air space combustion takes place with violence. One authority (Stockmeier) states that the powder is not ignited by friction, but mixed with potassium chlorate it is readily so ignited. Mixed with air, aluminum powder can be ignited by an electric spark, and it is thought that some explosions have been caused by sparks from electric fans. It has been noticed that when water is thrown in burning aluminum, large volumes of hydrogen are evolved. Leighton found that aluminum dust laid as a train on a soft wood board could be fired by short circuiting

a current through it, and that when water was thrown on the burning mass a violent puff resulted. It was also found that the dust sprinkled in iron at a dull red heat (about 600° C.) melted and stuck to the iron, but did not burn. Evidently the igniting point of aluminum dust is above that of coal dust. Commercial aluminum dust usually has a thin coating of oil, stearin or some similar substance, which serves to prevent oxidation, as the product loses its luster if not so coated.

The dust is so light that it is easily blown about and usually the articles in the workroom are covered with it. All apparatus should be tightly enclosed. If fan-suction is employed to carry off the waste, some form of dust precipitator should be attached a short distance from the grinding machine to minimize the risk of explosion. Explosions of flour dust often begin at the ventilating fans and spread to the rooms in which the dust is being produced. At the factories at which explosions of aluminum dust occurred, the ventilating systems seemed to be designed to keep the air in rapid motion, hence helped to suspend the material. There was no device to collect the dust.

It is well known that aluminum enters into combination with many elements with great heat disengagement. The heat of formation of aluminum oxide is nearly four times that of carbon dioxide. The metal also has a high specific heat, hence the difficulty of igniting it with small flames.

It is evident that the commercial manufacture of the dust involves serious risks, which should be met by scientific construction of the apparatus and proper ventilating systems. Suggestions along these lines are given in Leighton's paper.

H. L.

Cadmium Production in 1919. (*U. S. Geological Survey Press Bulletin*, No. 440, March, 1920.)—The output of metallic cadmium in 1919 was 99,939 pounds, compared to 127,164 pounds in 1918 and 207,408 pounds in 1917, the maximum output in the history of the industry. The production of cadmium sulphide was 31,197 pounds, compared with 51,702 pounds in 1918. The combined value of metallic cadmium and cadmium sulphide in 1919 was about $160,000, compared with $258,518 in 1918 and $376,036 in 1917. These figures computed by C. E. Siebenthal, are made public by the U. S. Geological Survey, Department of the Interior.

Though prices of cadmium were somewhat lower in 1919 than in the three years immediately preceding, the industry closed the year in better condition than in 1918, for the reason that the consumption practically reached the level established in 1916–17, and this with the decreased production operated to reduce stocks.

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